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**PL-TR-97-2139**

# **DESIGN AND DEVELOPMENT OF THE GENERIC CONTROLLER ASSEMBLY**

**Milton V. Farar  
William Graham**

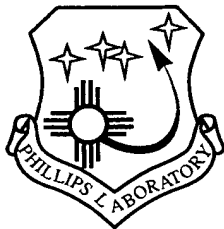
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84 South Street  
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**10 November 1997**

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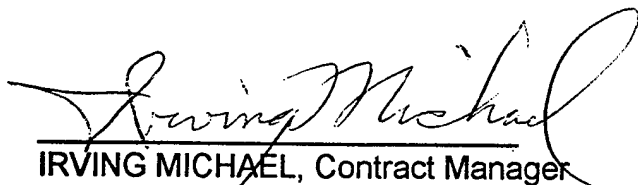
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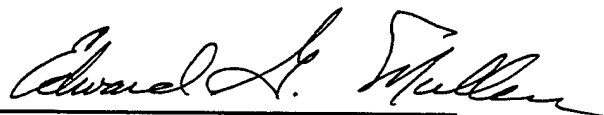
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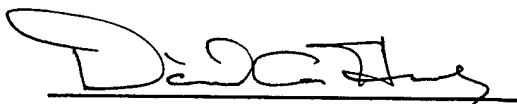
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## 1.0 INTRODUCTION

This is the Final Technical Report of Contract Number F19628-90-C-0138 for the design and development of the Generic Controller Assembly and is submitted as required by CDRL 104.

## 2.0 RESEARCH AND DEVELOPMENT DATA

### 2.1 GCA Technical Activity

Assurance Technology Corporation (ATC) successfully completed the objectives of the contract which were the design, development, fabrication, test and delivery of a microprocessor-based Generic Controller Assembly (GCA) to provide data acquisition and control of satellite-borne experiments. Deliverables included a brassboard and two (2) flight units.

ATC modified the GCA brassboard design and developed it as the charge analysis and wake studies (CHAWS) controller. The CHAWS Controller was delivered for system integration and test on 3 February 1992. The CHAWS was launched on STS60, 3-11 February 1994 and successfully completed its planned mission.

ATC modified the GCA flight unit designs and developed them as the Flight Model Discharge System (FMDS) Control Electronics and the FMDS Plasma Source Electronics (PSE). The FMDS system was launched successfully on 31 July 1995.

ATC developed and delivered the Real Time Data Acquisitions Systems (RTDS) as the primary Ground Support Equipment (GSE) for the FMDS. A down sized version of the RTDS was developed and delivered as the primary GSE for the CHAWS controller.

The remainder of this section includes the following items:

- Software Architecture - Details of the FMDS and CHAWS embedded software.
- FMDS Subsystems - A brief description of the FMDS major subsystems.
- Mechanical Design - Packaging details of the FMDS Controller, FMDS Plasma Source Electronics (PSE) and the CHAWS Controller.
- Materials, Processing and Parts - A brief discussion of the materials, processes and parts used on the GCA program.
- Real Time Data Acquisition System (RTDS) - A brief description of the RTDS, its function and operation.

#### 2.1.1 Software Architecture

This section describes in detail the FMDS embedded software architecture. The software organization is presented in Figure 1 and software interfaces are presented in Figure 2. Flow charts depicting interrupt service routines are presented in Figures 3 through 6. The CHAWS embedded software is a subset of the FMDS software. The CHAWS interrupt service routines are presented in Figures 7 through 9.

##### 2.1.1.1 Command Module

The Command Module reads the data stream from the FMDS command subsystem to form command words. These command words are parsed to determine which FMDS functions must be spawned and to generate any required telemetry.

All valid FMDS controller serial commands are sequences of at least two and at most thirty-one command words. The first word of any command sequence contains the command opcode and length. The opcode is contained in the upper byte, bits 8 through 15 inclusive. The length is contained in the lower byte, bits 0 through 7 inclusive. Error detection procedures are used on all commands to ensure correctness.

# SOFTWARE ORGANIZATION

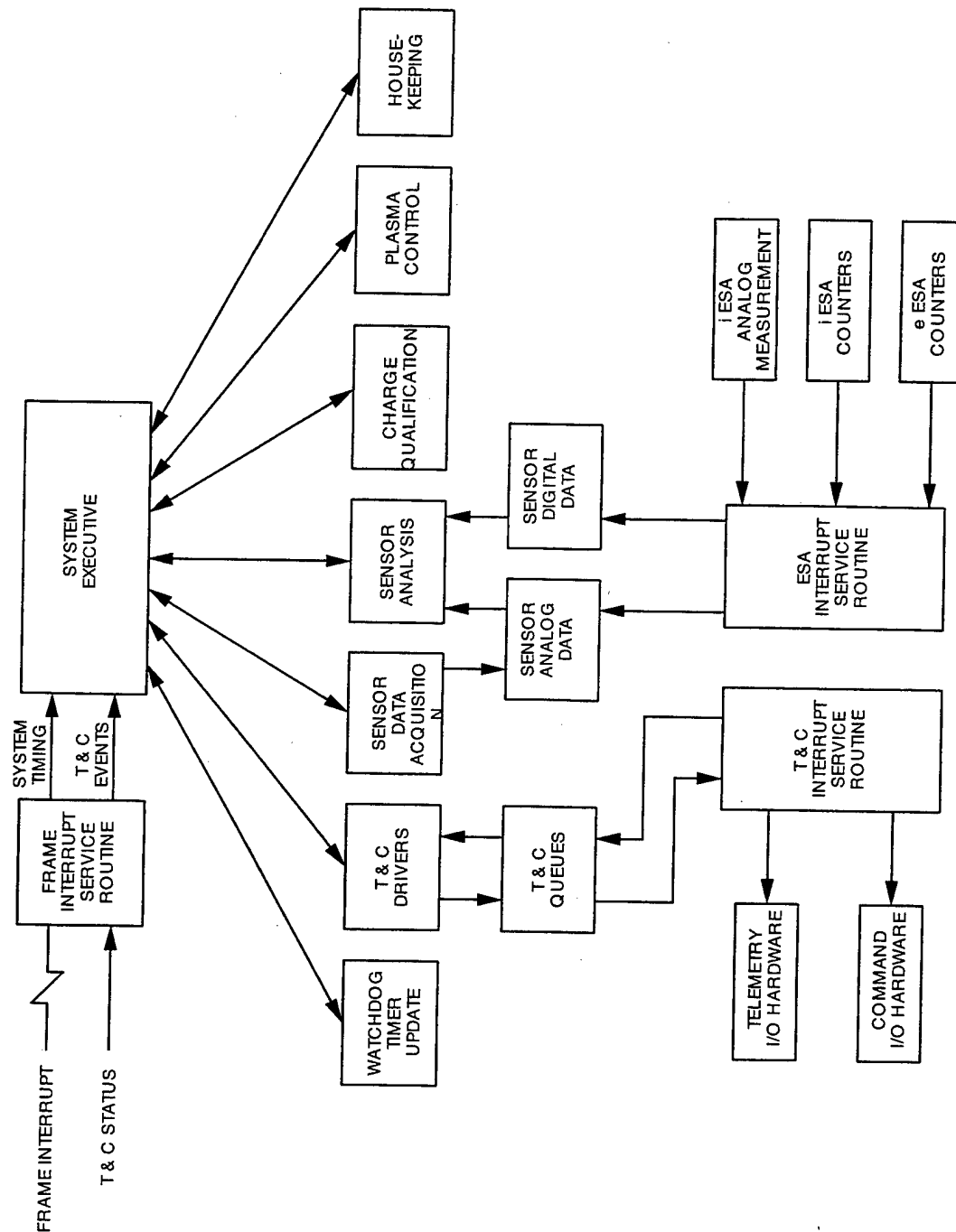
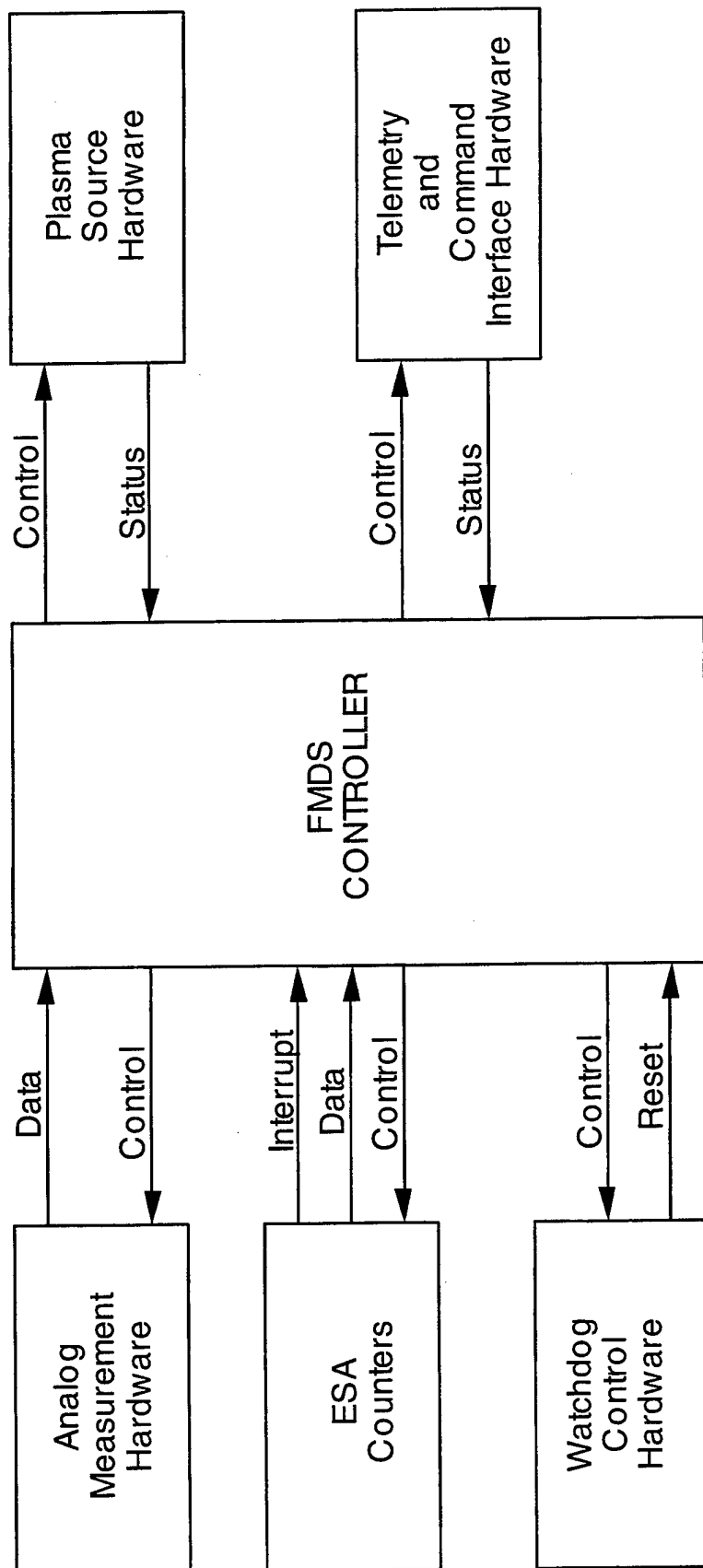


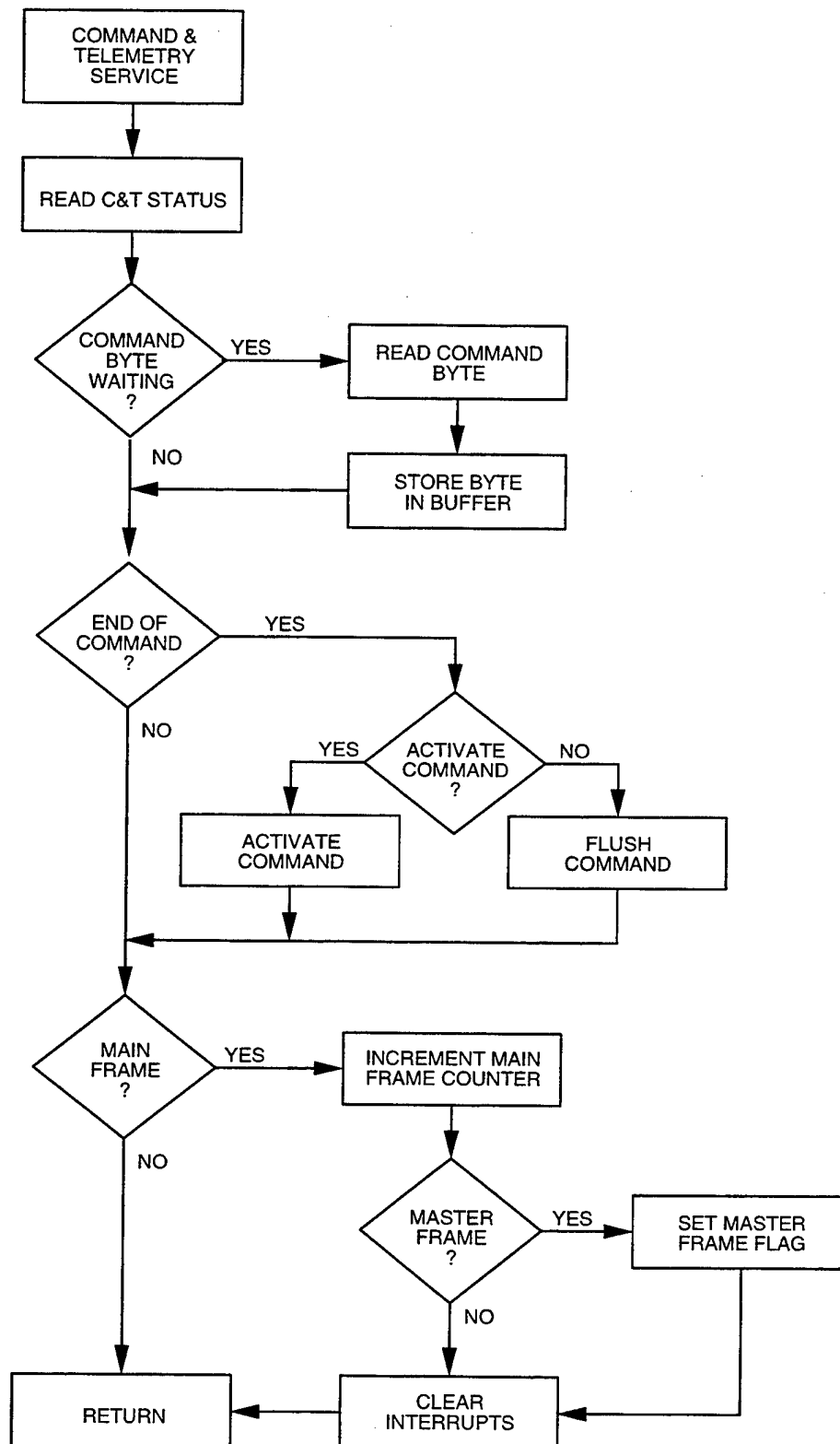
FIGURE 1: FMDS SOFTWARE ORGANIZATION

# INTERFACES



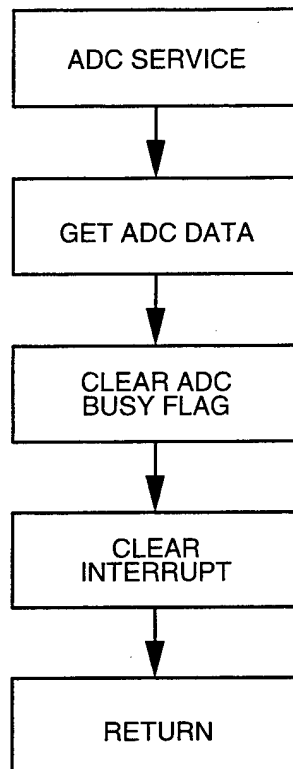
FMDS10-06140C

FIGURE 2: FMDS SOFTWARE INTERFACES



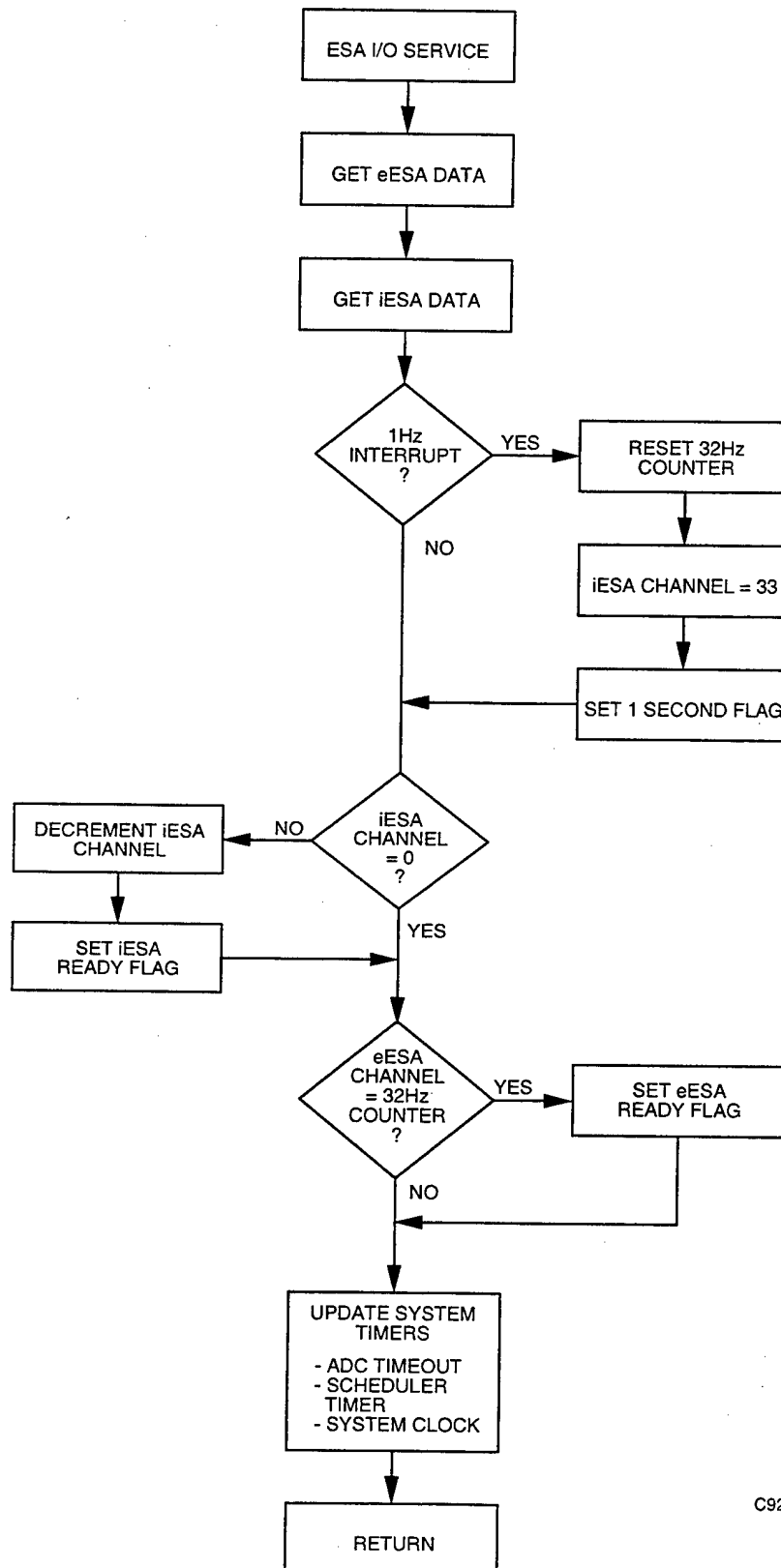
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FIGURE 3: FMDS INTERRUPT SERVICE ROUTINE FOR RST 5.5



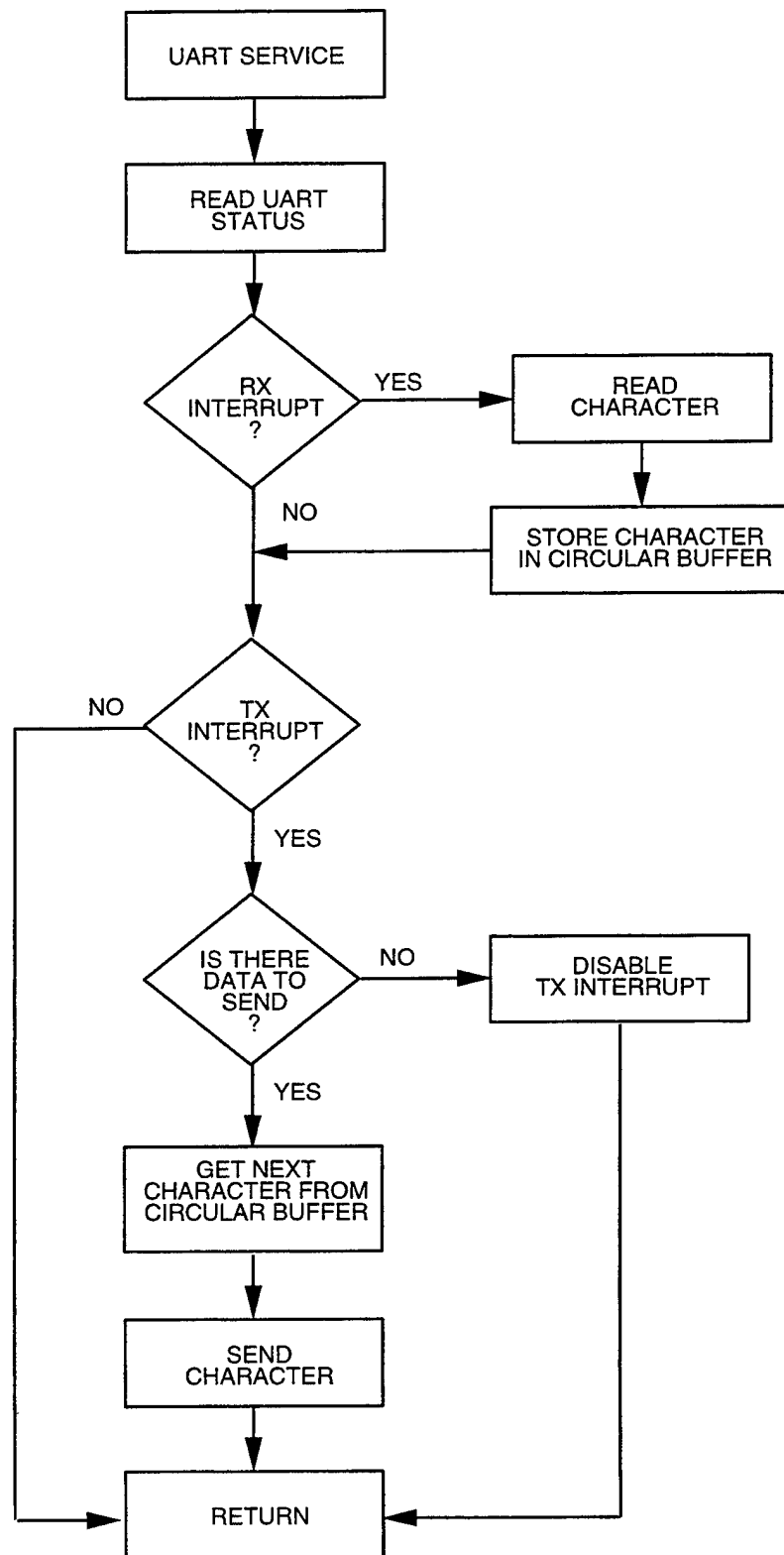
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FIGURE 4: FMDS INTERRUPT SERVICE ROUTINE FOR RST 6.5



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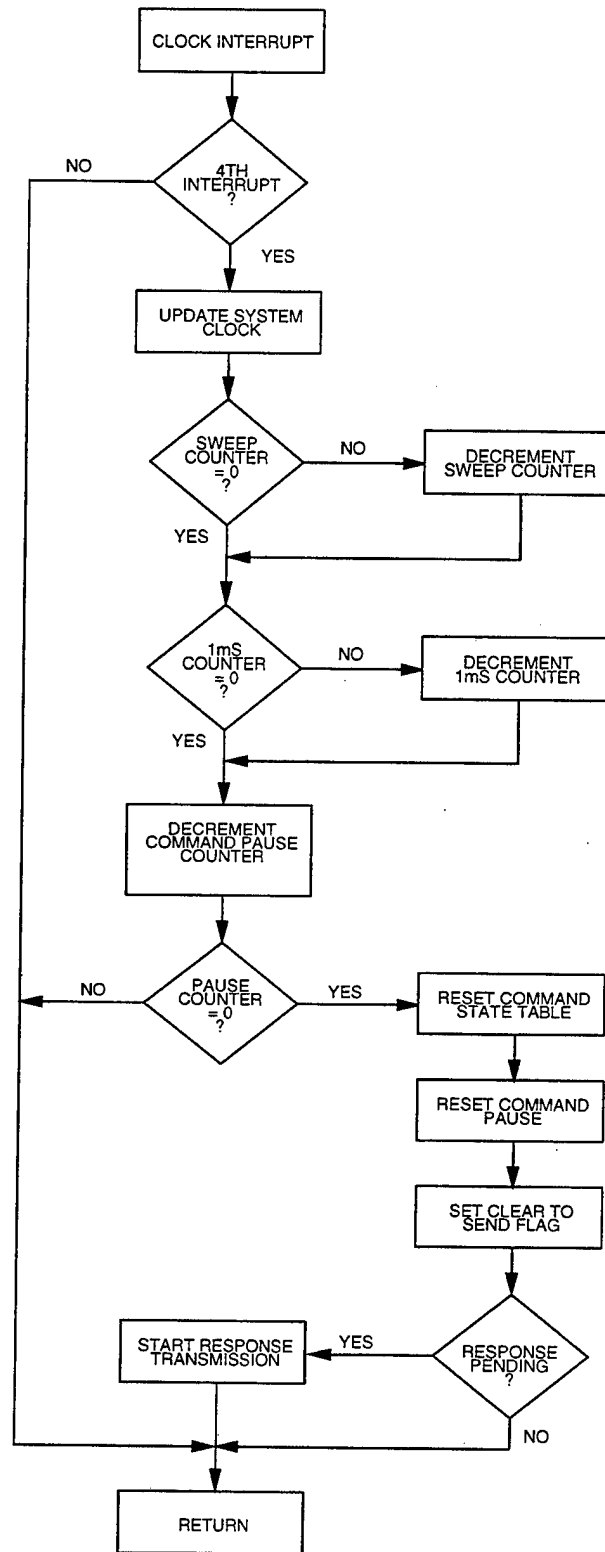
FIGURE 5: FMDS INTERRUPT SERVICE ROUTINE FOR RST 7.5



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FIGURE 6: FMDS INTERRUPT SERVICE ROUTINE FOR RST 5, 6, AND 7

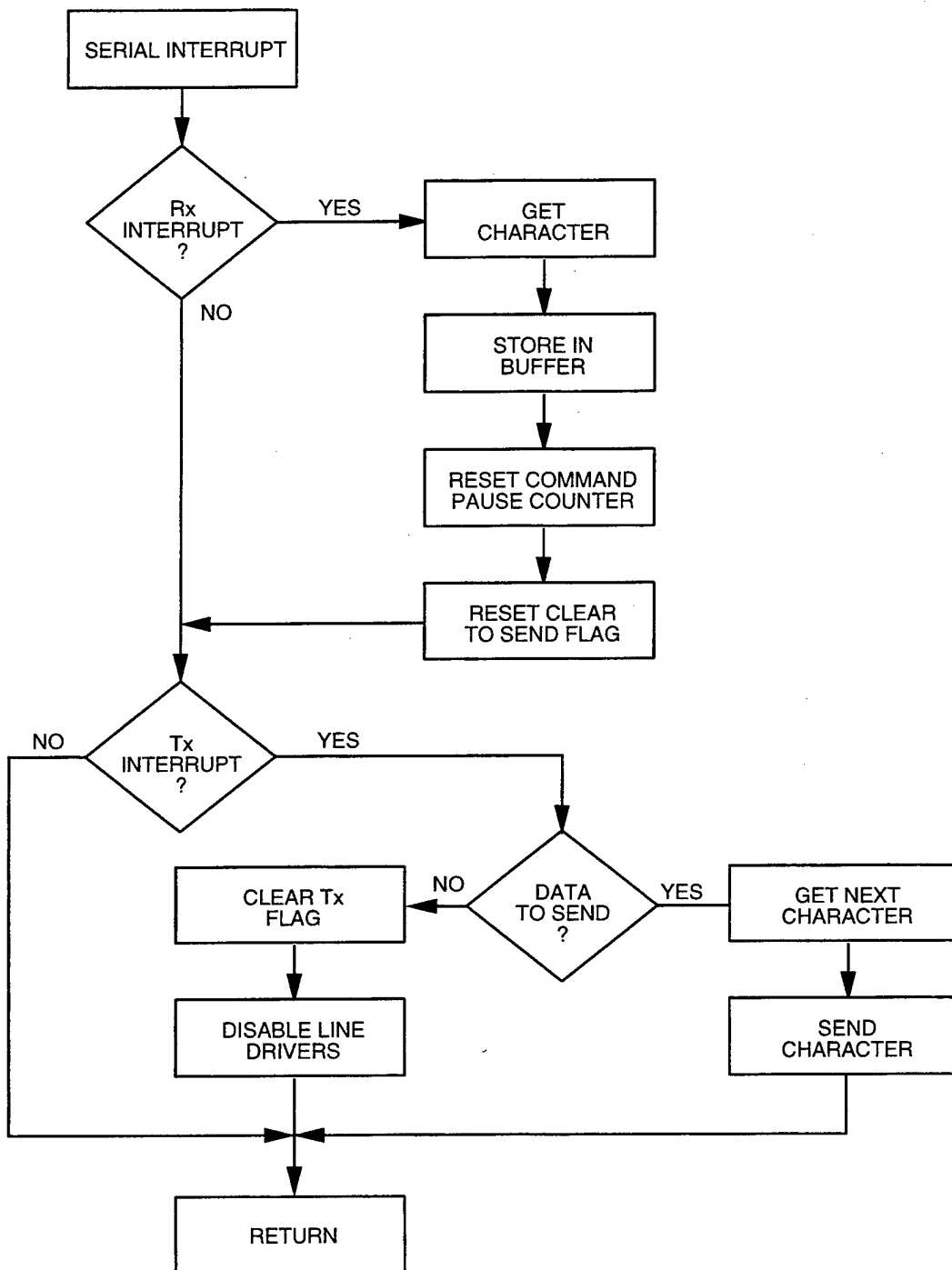
# TIMER/COUNTER #0 ISR



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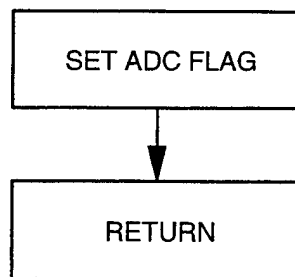
FIGURE 7: CHAWS INTERRUPT SERVICE ROUTINE FOR  
TIMER/COUNTER #0 ISR

## SERIAL INTERRUPT ISR



C92-6214

FIGURE 8: CHAWS INTERRUPT SERVICE ROUTINE FOR  
SERIAL INTERRUPT ISR



C92-6215

FIGURE 9: CHAWS INTERRUPT SERVICE ROUTINE FOR  
EXTERNAL INTERRUPT #0 ISR (ANALOG TO DIGITAL COMPLETE)

#### 2.1.1.1.1 Command Interrupt Service Routine (ISR)

The purpose of the command ISR is to handle the command byte interrupt from the FMDS command subsystem. This ISR places the command byte received in a circular buffer and sets a flag to tell the command processor that data is waiting.

#### 2.1.1.1.2 Command Event Timer

The purpose of the command event timer is to determine the end of a command word. The end of a command word is defined as a 4-second pause in the command stream.

#### 2.1.1.1.3 Command Processing

The command processing routines are used to maintain the command buffers and the interface to the FMDS executor. The command processor utilizes a double buffering technique to allow an incoming command to be received while simultaneously parsing a previously received command.

#### 2.1.1.1.4 Command Parsing

FMDS controller command words are divided into two word and multi-word commands. Two-word commands consist of a command word and its complement. The command word will contain the command opcode and the command data length (always a one in the case of two word commands). Multi-word commands vary in length between three and sixty-four words. Except for the Load Memory command, the size of any instance of a command is always the same. The first word of the command contains the opcode and length. There then follows an appropriate number of command data words. The final word of the command contains the Cyclic Redundancy Check CRC-16 value of all the command words excluding the CRC word itself.

Upon activation of the command parser module, error detection procedures are invoked on the command. If any procedure detects an error, the command is rejected and no further processing occurs on this command. After identifying a valid command, the parser spawns the requested function and generates any required telemetry.

#### 2.1.1.2 Telemetry Module

As seen by the FMDS controller telemetry interface, a "Master Frame" consists of 30 "Main Frames" of fourteen bytes each. Thus, a 61.44 second "Master Frame" yields 420 bytes of telemetry.

The available telemetry bandwidth has been parceled into two distinct areas: fixed and packetized. Of the 420 bytes of telemetry available every master frame period, 196 bytes are used by the fixed area and 224 bytes are used in the packetized area.

##### 2.1.1.2.1 Telemetry Interrupt Service Routine (ISR)

The telemetry ISR is used to pass telemetry data to the FMDS telemetry subsystem. Telemetry data bytes pending transmission are held in a circular buffer.

##### 2.1.1.2.2 Telemetry Packet Driver

This driver is used to gather telemetry packets from the various FMDS subsystems and to pass the data to the telemetry ISR. The packetized area is maintained to support the flexibility required in a spaceborne application. This area will be used to support iESA data whenever the bandwidth is available.

#### 2.1.1.2.3 Fixed Format Processing

This routine is used to pass a snapshot of the fixed format telemetry to the telemetry ISR. The information in the fixed area is positional sensitive.

#### 2.1.1.2.4 Application Queue Interface

This interface is used by the telemetry packet driver to handle telemetry packet requests from FMDS subsystems (i.e. sensor processor).

#### 2.1.1.2.5 eESA Data Processing

This routine is used by the telemetry ISR to fill available telemetry bandwidth with eESA data.

#### 2.1.1.3 Sensor Processing Module

The Sensor Processing Module reads data from the various FMDS sensors to determine if the platform is in a charged state. The methods used to determine sensor state of charge and platform state of charge are outlined below.

##### 2.1.1.3.1 SPM1, SPM2 & eESA Control

These routines are used to read data from the FMDS sensors. The results of these readings are used to determine the state of the Charge/No Charge Flag for each sensor.

##### 2.1.1.3.2 SPM<sub>1/2</sub> Charge

The following is the procedure used to determine an SPM charged condition.

- a. read 8 bit SPM<sub>1/2</sub> ADC values once every ten seconds  
{note: 1 bit = 30 mV}
- b. put data in telemetry
- c. if SPM<sub>1/2</sub> value > [SPM\_threshold<sub>1/2</sub>(128)] then  
increment SPM\_times\_charged<sub>1/2</sub> else  
SPM\_times\_charged<sub>1/2</sub> = 0.
- d. if SPM\_times\_charged<sub>1/2</sub> > [SPM\_smoothing<sub>1/2</sub> (3)] then  
set SPM\_charged\_flag<sub>1/2</sub> else reset SPM\_charged\_flag<sub>1/2</sub>.

#### 2.1.1.3.3 eESA Charge

The following is the procedure used to determine an eESA charged condition.

- a. read 16 bit counter value once a second
- b. put value in telemetry
- c. if value > [eESA\_threshold (TBS)] then increment  
eESA\_times\_charged else eESA\_times\_charged = 0.
- d. if eESA\_times\_charged > [eESA\_smoothing (5)] then set  
eESA\_charged\_flag else reset eESA\_charged\_flag.

#### 2.1.1.3.4 iESA Control

The iESA data is not used by the controller to determine state of charge. Data collected from the iESA is simply placed in the telemetry stream. The following is the procedure used to process iESA data.

- a. read 15 bit count and 8 bit plate voltage 32 times a second (one sweep = 32 steps)

- b. put 32 count/voltage pairs in telemetry as bandwidth permits

#### 2.1.1.3.5 Sensor Process Control

This routine is responsible for determining if the FMDS platform is in a charged state. This routine uses the sensor Charge/No Charge Flags and a rules table to make this determination. If the platform is in a charge state this module will set the Charged Flag.

#### 2.1.1.3.6 System Charge Determination

Depending on the plasma\_mode the system\_charged flag is set when the proper combination of sensor charged flags are set. The table below shows the sensor charged flags combinations for each plasma\_mode. (mode 7 is default)

mode 0:	Ground command only
mode 1:	eESA_charged_flag
mode 2:	SPM1_charged_flag
mode 3:	SPM2_charged_flag
mode 4:	eESA_charged_flag or SPM1_charged_flag
mode 5:	eESA_charged_flag or SPM2_charged_flag
mode 6:	SPM1_charged_flag or SPM2_charged_flag
mode 7:	eESA_charged_flag or SPM1_charged_flag or SPM2_charged_flag

#### 2.1.1.4 Charge Control Processing Module

The Charge Control Processing Module reads the Charged Flag controlled by the Sensor Processing Module and uses a rules table to determine if a discharge is required. If a discharge is required this module will set a Discharge Request Flag.

#### 2.1.1.4.1 Discharge Request

If all of the following conditions are met the discharge\_request flag will be set.

1. not in plasma mode 0
2. system\_charged flag is set
3. the discharge\_request flag has not been set for at least [plasma\_off\_min (450)] minutes

If the system is not in plasma mode 0 then any one of the following conditions will reset the discharge\_request flag.

1. the discharge\_request flag has been set for a minimum of [plasma\_on\_min (1800)] seconds and the system\_charged flag is not set
2. the discharge\_request flag has been set for at least [plasma\_on\_max (3600)] seconds and the plasma\_max\_override flag is not set.

#### 2.1.1.5 Plasma Source Electronics Processing Module

This module reads the Discharge Request Flag and uses a rules table to determine which Plasma Source Electronics Actions are required.

##### 2.1.1.5.1 Analog Channels Processing

These routines are used to read and process data from the Analog to Digital Converter. A reading is made by first selecting the desired channel from the analog multiplexer and then requesting a conversion. All readings made by this module are offset by a reading made from the ground reference.

#### 2.1.1.5.2 Hardware Relays

These routines are use to control the various FMDS relays. Both pulsed and bi-level relays are controlled by this module.

#### 2.1.1.5.3 Rules Implementation

An extensive rules table is used to determine proper control sequences (i.e., On, Off, Retry, etc.) and to detect plasma source turn on and failure.

#### 2.1.1.5.4 Turn On Procedure (Plasma Source)

The following outlines the plasma source turn on procedure. This procedure can be spawned manually by ground command or autonomously by platform charge.

- a. set discharge current and keeper current levels  
(D/K1=1,D/K0=0)
- b. confirm that all valves are closed (V1OFF,V2OFF,V3OFF)
- c. open high pressure valve (V3ON)
- d. open bypass valve (V2ON) - wait 10 seconds
- e. close bypass valve (V2OFF)
- f. keeper supply on (KEEPERON/OFF) - wait 2 seconds
- g. discharge supply on (DISON/OFF) - wait 2 seconds

#### START

- h. open low pressure valve (V1ON) - wait 10 seconds
- i. while discharge\_request flag is set monitor keeper current. if keeper current falls below 25 mA initiate a retry cycle.

#### NORMAL SHUTDOWN

- j. keeper supply off (KEEPERON/OFF)
- k. discharge supply off (DISON/OFF)
- l. close low pressure valve (V1OFF)
- m. if retry cycle go to step <d>
- n. close high pressure valve (V3OFF)

#### ANODE MODE OPTION (replace step <i> with the following)

- 1. raise discharge current and lower keeper current  
(D/K1=0,D/K0=1) - wait 5 seconds
- 2. while discharge\_request flag is set monitor keeper current. if keeper current falls below 25 mA initiate a retry cycle.

#### NOTE

After [plasma\_tries (4)] retries - full off until ground commandable reset.

#### 2.1.1.5.5 Reconditioning

Plasma Source reconditioning is performed after [plasma\_cycle\_limit (100)] operating cycles of the plasma source. The following outlines the reconditioning process.

- a. confirm discharge supply and keeper supply are off  
(DISON/OFF,KEEPERON/OFF)
- b. heater on - low heat mode for [low\_heat\_time (3)] hours  
(HTR0=0,HTR1=0,HTRON/OFF)
- c. heater off for [off\_heat\_time (30)] minutes (HTRON/OFF)

- d. heater on - high heat mode for [high\_heat\_time (1)]  
hour (HTR0=1,HTR1=1,HTRON/OFF)
- e. heater off (HTRON/OFF)

#### 2.1.1.6 Scheduler Module

The scheduler module is used to queue tasks to be executed at a specified time. The scheduler has a 1/4 second resolution. This module is used extensively by the system executor.

#### 2.1.1.7 Bootstrap Load Module

The Bootstrap Load Module is responsible for initializing all of the various FMDS modules and test the health and well being of the system at power on. This module is executed in response to the following events: system power up, in response to a system restart command, and after watchdog reset. An outline of the bootstrap load procedure is shown below.

1. pulse watchdog timer.
2. initialize the telemetry processor.
3. initialize the command processor.
4. initialize the scheduler.
5. initialize the test port (UART).
6. initialize the sensor processor.
7. initialize the sensor charge processor.
8. initialize the platform charge processor.
9. initialize the high resolution window processor.
10. initialize the plasma source electronics processor.
11. clear the fixed format telemetry area.
12. reset the command timer.
13. queue up a start-up initiated packet.
14. take a snapshot of the fixed format telemetry area.

15. start up watchdog timer reset routines.
16. start up SPM sensor monitor.
17. start up eESA sensor monitor.
18. start up sensor control system.
19. start up charge control system.
20. start up plasma source electronics processing system.
21. start-up high resolution window processor.
22. set keeper current to 250 mA.
23. set discharge current to 200 mA.
24. turn off heater.
25. turn off keeper supply.
26. turn off discharge supply.
27. set heater in low heat mode (2.25 amp).
28. close all valves.
29. turn on all sensors.
30. turn off plasma source.
31. start up system executor.

#### 2.1.1.8 Housekeeping Module

The Housekeeping Module is responsible for maintaining the system flags and system clock.

#### 2.1.1.9 Diagnostics Module

The Diagnostic routines are used to test the RAM, ROM and ADC subsystems.

##### 2.1.1.9.1 RAM Diagnostics

The RAM diagnostic does a non-destructive bit test of each byte of RAM.

#### 2.1.1.9.2 ROM Diagnostics

The ROM diagnostic computes a checksum of the ROM.

#### 2.1.1.9.3 ADC Diagnostics

The ADC diagnostic tests the Analog to Digital Converter by reading the 0.0 V, the 2.5 V, and the 5.0 V reference points.

### 2.1.2 Controller Subsystems

This section provides a brief description of the major controller subsystems. Each subsystem is implemented on a Circuit Card Assembly (CCA). As reported in the last report, the FMDS Plasma Source Electronics has been packaged in a separate housing.

#### 2.1.2.1 Backplane CCA

The backplane consists of six 60-pin sockets. The first five sockets are used to connect the five major CCAs. The sixth socket is designated as a test socket and can be accessed from outside of the controller unit by removing a small cover. Power is delivered to the backplane from an external DB9 style connector. Power levels include ground, +15, -15, +10 and +5 V.

#### 2.1.2.2 Microprocessor CCA

The microprocessor CCA is completely self contained including all memory and support chips. The microprocessor CCA is based on the Sandia SA3000 RAD hard ( $1 \times 10^5$ ) microprocessor and support chips operating at 1.048 MHz (50% of maximum rate). The SA3000 is hardware and software compatible with the Intel 8085. Eight 2Kx8 CMOS RAD hard PROMs contain mission software and eight

CMOS RAD hard RAMs are utilized for scratch pad, data storage, and for ground generated program modifications.

#### 2.1.2.3 A/D Converter CCA

The A/D Converter CCA is a 32 channel, 10 mV/Bit dual slope integrating analog to digital converter with a 2 ms conversion time. The A/D Converter CCA is implemented using low power CMOS and analog parts.

The following analog levels can be accessed through this CCA.

- a. Discharge Voltage
- b. Discharge Current
- c. Heater Voltage
- d. Heater Current
- e. Keeper Voltage
- f. Keeper Current
- g. Main Bus Voltage
- h. Main Bus Current
- i. High Pressure Transducer
- j. Low Pressure Transducer
- k. +15 V Monitor
- l. -15 V Monitor
- m. +10 V Monitor
- n. +5 V Monitor
- o. PSE Temperature 1
- p. PSE Temperature 2
- q. ESA Temperature
- r. SPM 1 Sun Sensor
- s. SPM 2 Sun Sensor
- t. Log Electrometer Current
- u. +2.5 Reference Voltage
- v. SPM 1 Sensor Output
- w. SPM 2 Sensor Output

- x. Ion ESA Sweep Output
- y. Electron ESA Sweep Output

#### 2.1.2.4 FMDS I/O CCA

The FMDS I/O CCA contains 16 one-shot control signals, 8 bi-level control signals, 8 digital inputs, and the watchdog timer circuitry.

The one-shot control signals are used for the following.

- a. close high pressure valve
- b. open high pressure valve
- c. close bypass valve
- d. open bypass valve
- e. close low pressure valve
- f. open low pressure valve
- g. turn off plasma source
- h. turn on plasma source
- i. turn off SPM 2
- j. turn on SPM 2
- k. turn off ESA
- l. turn on ESA
- m. turn off SPM 1
- n. turn on SPM 1

The bi-level control signals are used for the following.

- a. turn the heater on and off
- b. turn the keeper supply on and off
- c. turn the discharge supply on and off
- d. set the discharge current high or low
- e. set the keeper current high or low

- f. set/reset heater mode bit 0
- g. set/reset heater mode bit 1

The digital inputs are used to read the following.

- a. SPM 1 range
- b. SPM 2 range

#### 2.1.2.5 Command & Telemetry CCA

The Command & Telemetry CCA is used to interface with the satellite. All of the command and telemetry signals are redundant. This CCA handles all communication between the CPU and the satellite's active command and telemetry channel.

#### 2.1.2.6 ESA I/O CCA

The ESA I/O CCA contains the following functional modules.

- A 20 bit synchronous counter for generating 1.040 MHz to 1 Hz clocks. This counter generates all of the clocks required by the controller and the ESAs.
- An ion counter. The ion counter is sampled by the CPU 32 times per second. The MSB of the ion counter latch is used to send the 1 second flag to the CPU.
- An electron counter. The electron counter is sampled by the CPU once per second.

#### 2.1.2.7 UART CCA

The UART CCA is used during test and verification only, and is not part of the final flight unit. The UART CCA plugs into the backplane from outside the controller through a small

test port. This CCA provides the ability to test the health and well being of the controller using a standard VT-100 terminal.

#### 2.1.2.8 Plasma Source Electronics (PSE)

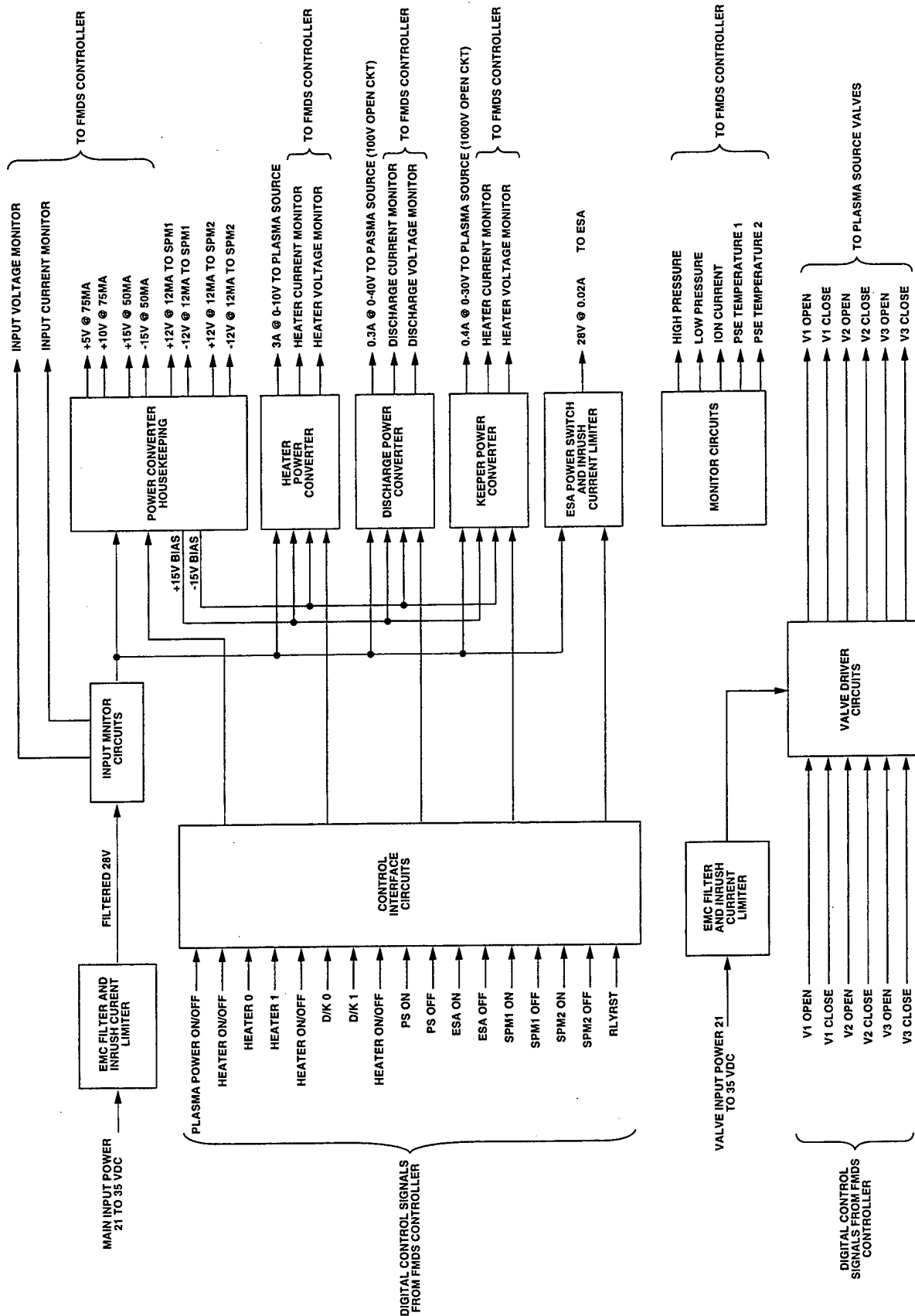
In order to meet FMDS Program requirements, the FMDS power supply is being packaged separately in its own housing and hereafter will be referred to as the FMDS Plasma Source Electronics (PSE). The PSE is primarily a power conditioning subsystem which receives prime power from the spacecraft and provides operational power for other FMDS subsystem components including the FMDS Controller, Plasma Generator, Surface Potential Monitors (SPM) and the Electrostatic Analyzer (ESA). The PSE also provides a number of control and monitoring functions.

A functional block diagram of the PSE is shown in Figure 10. Power conversion functions within the PSE are represented as the Housekeeping, Heater, Discharge and Keeper Power Converters.

The Housekeeping Power Converter provides power to the FMDS Controller and the two Surface Potential Monitors (SPM). The Housekeeping Power Converter also provides internal PSE power including bias power for the remaining three converters. The Heater, Keeper and Discharge Power Converters power the plasma source which requires special power conditioning and control functions. These functions are implemented within the converters and sequenced and operated by the FMDS Controller. The heater and discharge power converters are six-layer printed circuit boards and the keeper power converter consists of a six-layer and a four-layer printed circuit board.

The PSE provides ON/OFF control of all subsystems (except the controller) by power switching. ESA power is derived directly from spacecraft input power and switched by the PSE with

an inrush limited switch. The PSE also contains plasma source valve drivers which are operated by the controller to open and close the latching valves associated with gas flow to the plasma source.



C32-6438

FIGURE 10: BLOCK DIAGRAM - FMDS PLASMA SOURCE ELECTRONICS (PSE)

In addition to accepting commands from the controller, the PSE provides the controller with eight analog monitors which indicate voltage and current of prime power and of each of the three plasma source outputs.

Additional monitors are provided by special analog signal processing circuitry. Two amplifier/buffer circuits are used in conjunction with gas pressure transducers on the plasma source to provide the controller with gas pressure data. Ion current is measured and provided as analog data to the controller by a logarithmic electrometer. Two thermistor based temperature indicators provide PSE temperature monitoring.

Input filters and inrush current limiters are included at the spacecraft power inputs. One of these inputs, "Main Input Power", is used for operation of all power converters and functions except the valve drivers. The valve drivers use a separate spacecraft power input, "Valve Input Power".

### 2.1.3 Mechanical Design

#### 2.1.3.1 FMDS Assembly Packaging

The FMDS Controller is packaged in an aluminum housing constructed of custom machined plates typically 0.100 inch wall thickness on all sides with support ribs machined into the plates. The FMDS is partitioned to accommodate the plugging-in of five Printed Circuit Board (PCB) assemblies into a single backplane assembly. ATC has found this approach to be superior to an interwired or integrated PCB assembly in the areas of assembly and test simplicity and reduced impact of rework and repair, resulting in high system reliability.

All of the PCB's, including the backplane, are multilayer with six layers being typical. The multilayer construction achieves high levels of thermal as well as

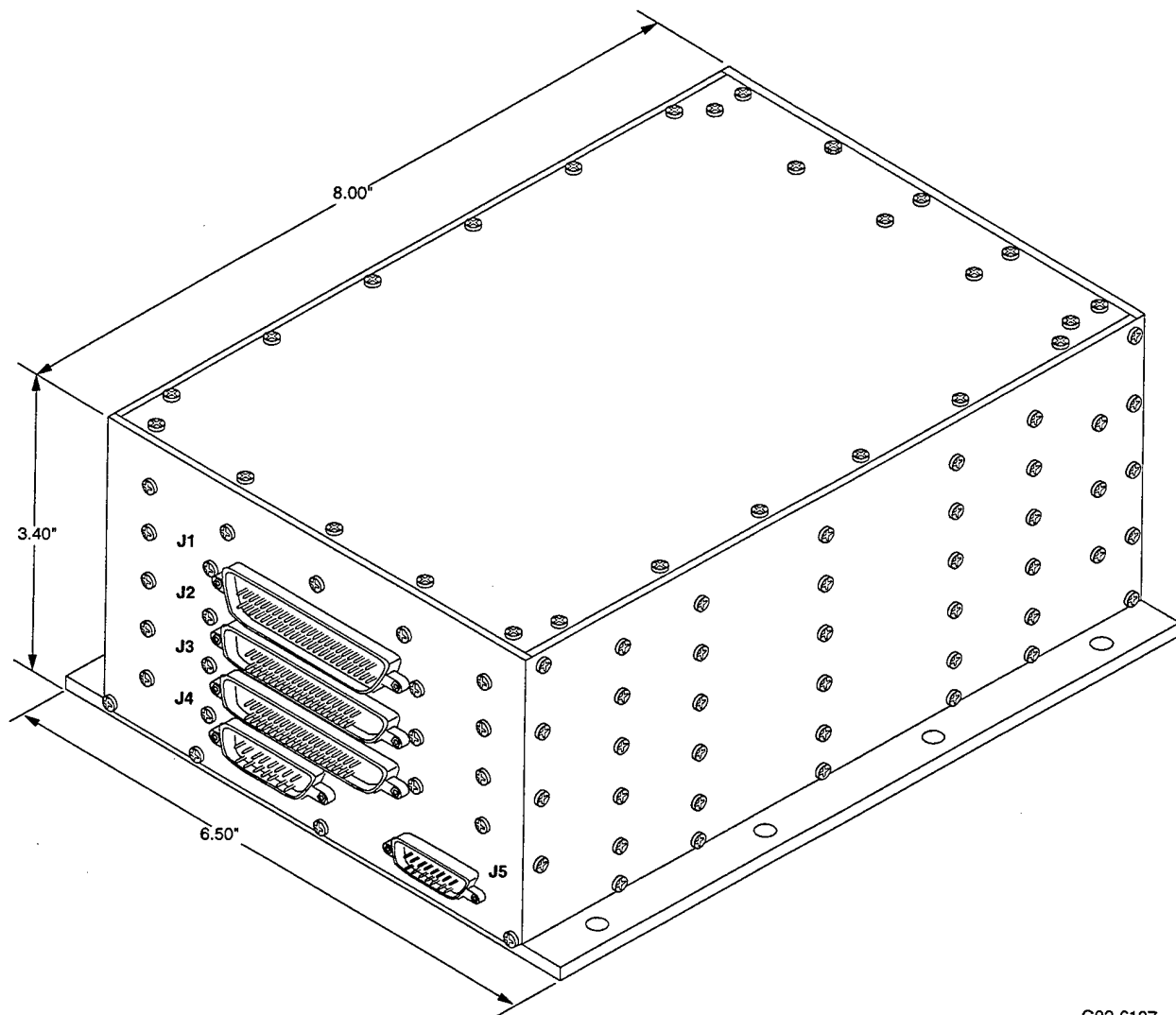
electrical conductivity. Each PCB is attached to a custom designed frame and the entire assembly is mounted horizontally into a backplane located at the rear of the housing. The frame is attached to each side of the housing thus satisfying the vibration and heat dissipation requirements of the FMDS mission.

The packaging approach described in this section results in the housing presented in Figure 11. The FMDS interface control diagram is presented in Figure 12. The finish dimensions are 6.50 inches wide by 8.00 inches long by 3.40 inches high with a total weight of 5.5 lbs. A mounting flange is located on either side of the housing for mounting purposes

#### 2.1.3.2 PSE Assembly Packaging

The PSE is packaged in an aluminum housing constructed of custom machined plates typically 0.100 inch wall thickness on all sides with support ribs machined into the plates. The PSE is partitioned to accommodate the plugging-in of six Printed Circuit Board (PCB) assemblies into a single backplane assembly. ATC has found this approach to be superior to an interwired or integrated PCB assembly in the areas of assembly and test simplicity and reduced impact of rework and repair, resulting in high system reliability.

All of the PCB's, including the backplane, are multilayer with six layers being typical. The multilayer construction achieves high levels of thermal as well as electrical conductivity. Each PCB is attached to a custom designed frame and the entire assembly is mounted horizontally into a backplane located at the rear of the housing. The frame is attached to each side of the housing thus satisfying the vibration and heat dissipation requirements of the FMDS mission.



C92-6197

FIGURE 11: VIEW OF FMDS CONTROL ELECTRONICS

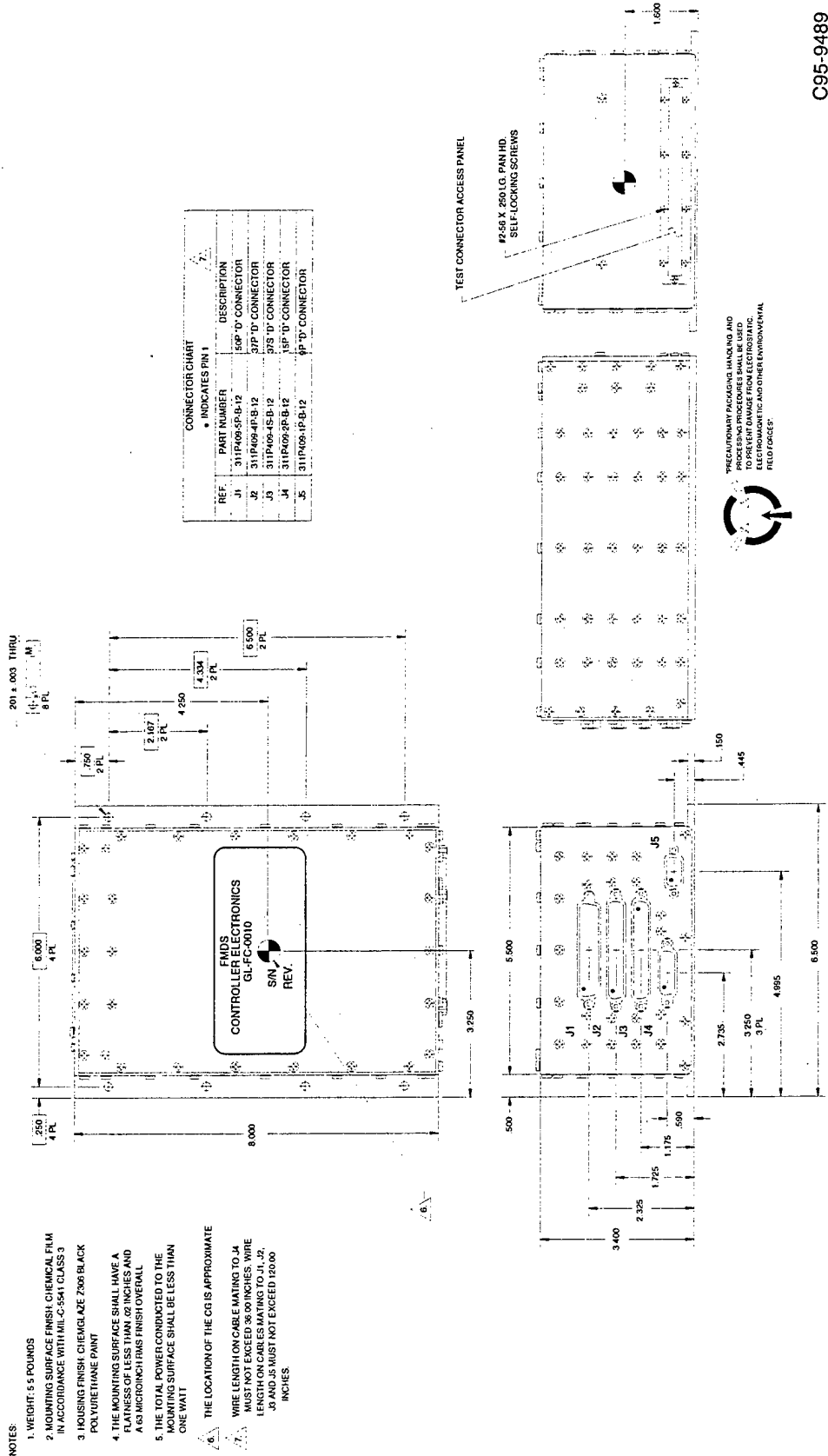


FIGURE 12: FMDS CONTROL ELECTRONICS ICD

The packaging approach described in this section results in the housing presented in Figure 13. The PSE interface control diagram is presented in Figure 14. The finish dimensions are 6.50 inches wide by 6.00 inches long by 7.00 inches high with a total weight of 8.0 lbs. A mounting flange is located on either side of the housing for mounting purposes.

#### 2.1.3.3 CHAWS Assembly Packaging

The CHAWS Controller is packaged in an aluminum housing constructed of custom machined plates typically 0.100 inch wall thickness on all sides with support ribs machined into the plates. The CHAWS is partitioned to accommodate the plugging-in of four Printed Circuit Board (PCB) assemblies into a single backplane assembly. ATC has found this approach to be superior to an interwired or integrated PCB assembly in the areas of assembly and test simplicity and reduced impact of rework and repair, resulting in high system reliability.

All of the PCBs, including the backplane, are multilayer with six layers being typical. The multilayer construction achieves high levels of thermal as well as electrical conductivity. Each PCB is attached to a custom designed frame and the entire assembly is mounted vertically into a backplane located at the bottom of the housing. The frame is attached to each side of the housing; thus, satisfying the vibration and heat dissipation requirements of the CHAWS mission.

The packaging approach described in this section results in the housing presented in Figure 15. The CHAWS interface control diagram is presented in Figure 16. The finish dimensions are 5.22 inches wide by 7.00 inches long by 7.00 inches high with a total weight of 4.75 lbs. A mounting flange is located on either side of the housing for mounting purposes.

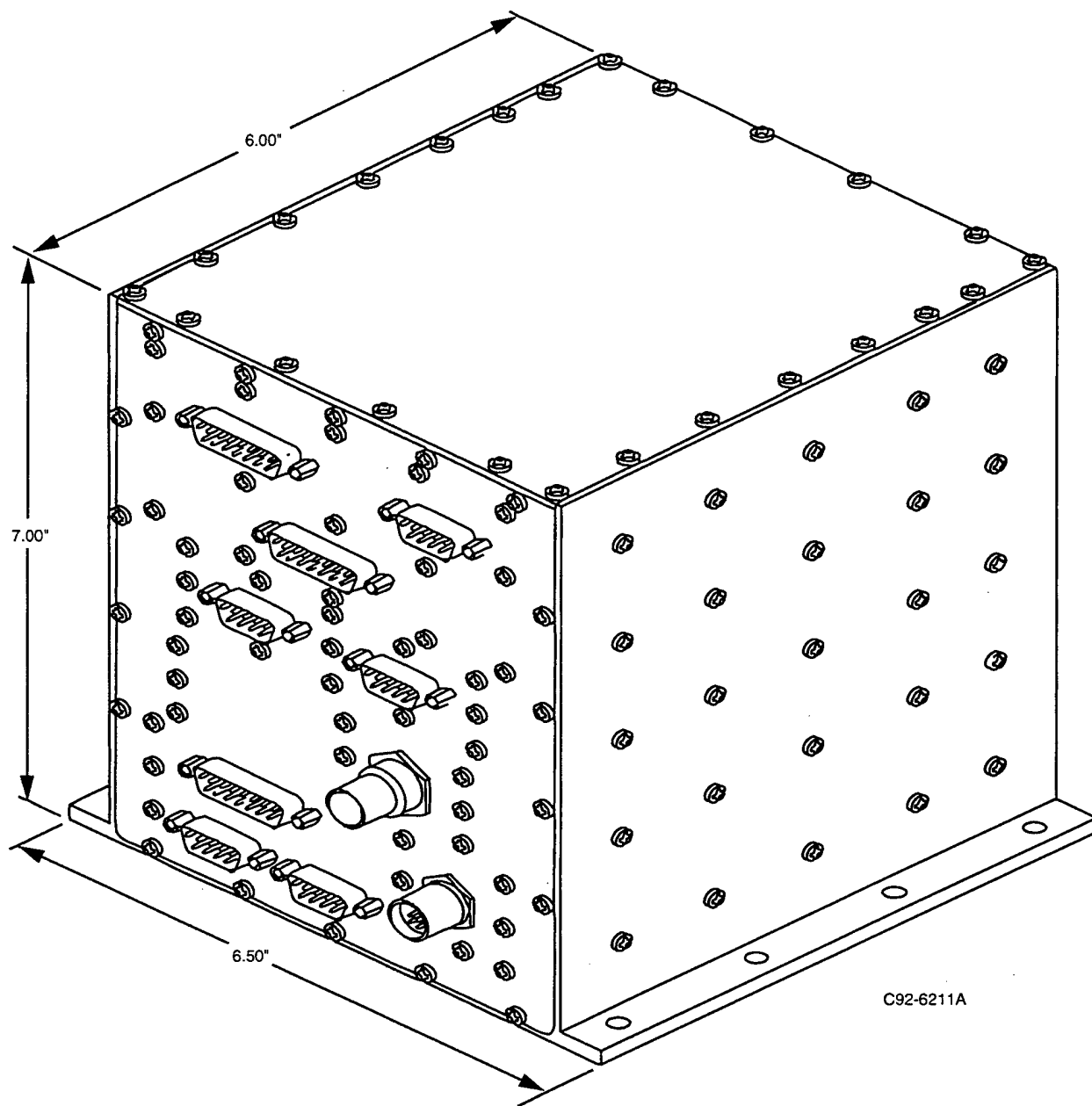


FIGURE 13: VIEW OF FMDS PLASMA SOURCE ELECTRONICS (PSE)

- NOTES:
1. WEIGHT: 9.0 POUNDS MAX
  2. MOUNTING SURFACE FINISH: CHEMICAL FILM IN ACCORDANCE WITH MIL-C-5541 CLASS 3
  3. HOUSING FINISH: CHEMGLAZE 2306 BLACK POLYURETHANE PAINT
  4. THE MOUNTING SURFACE SHALL HAVE A FLATNESS OF LESS THAN .02 INCHES AND A .63 MICRON RING FINISH OVERALL
  5. THE TOTAL POWER CONDUCTED TO THE MOUNTING SURFACE SHALL BE LESS THAN 180 WATTS
  6. THE LOCATION OF THE CG IS APPROXIMATE

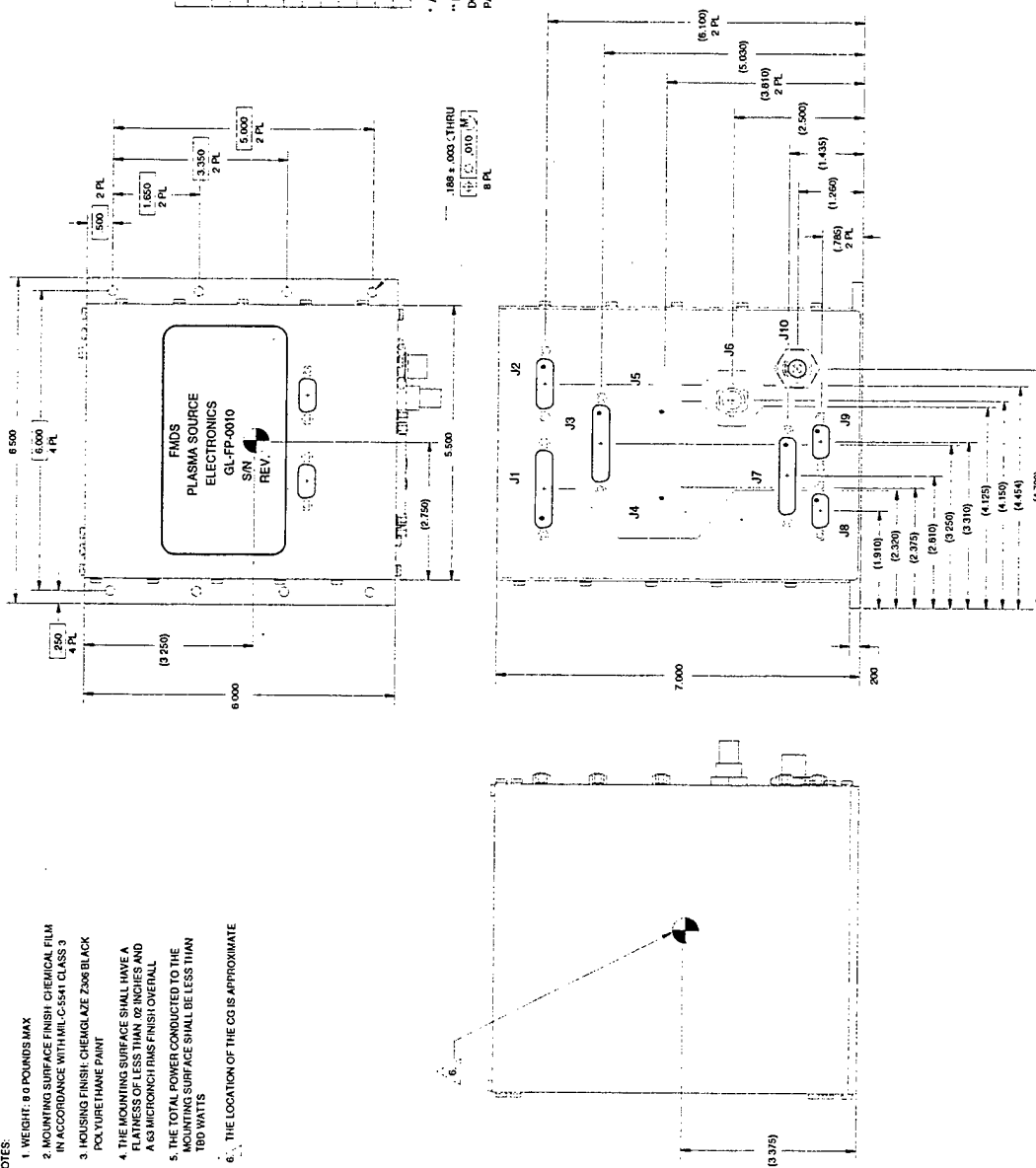
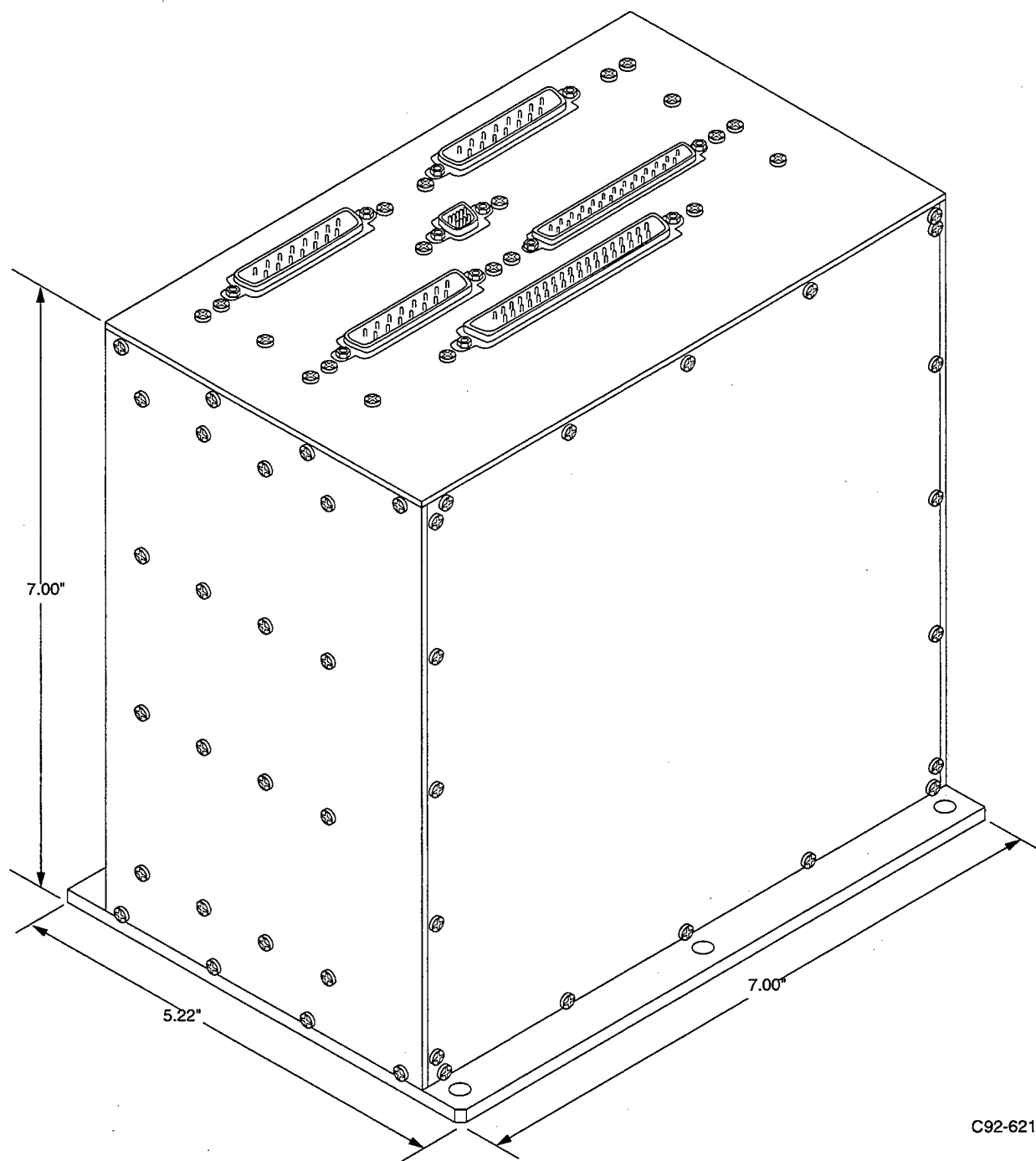
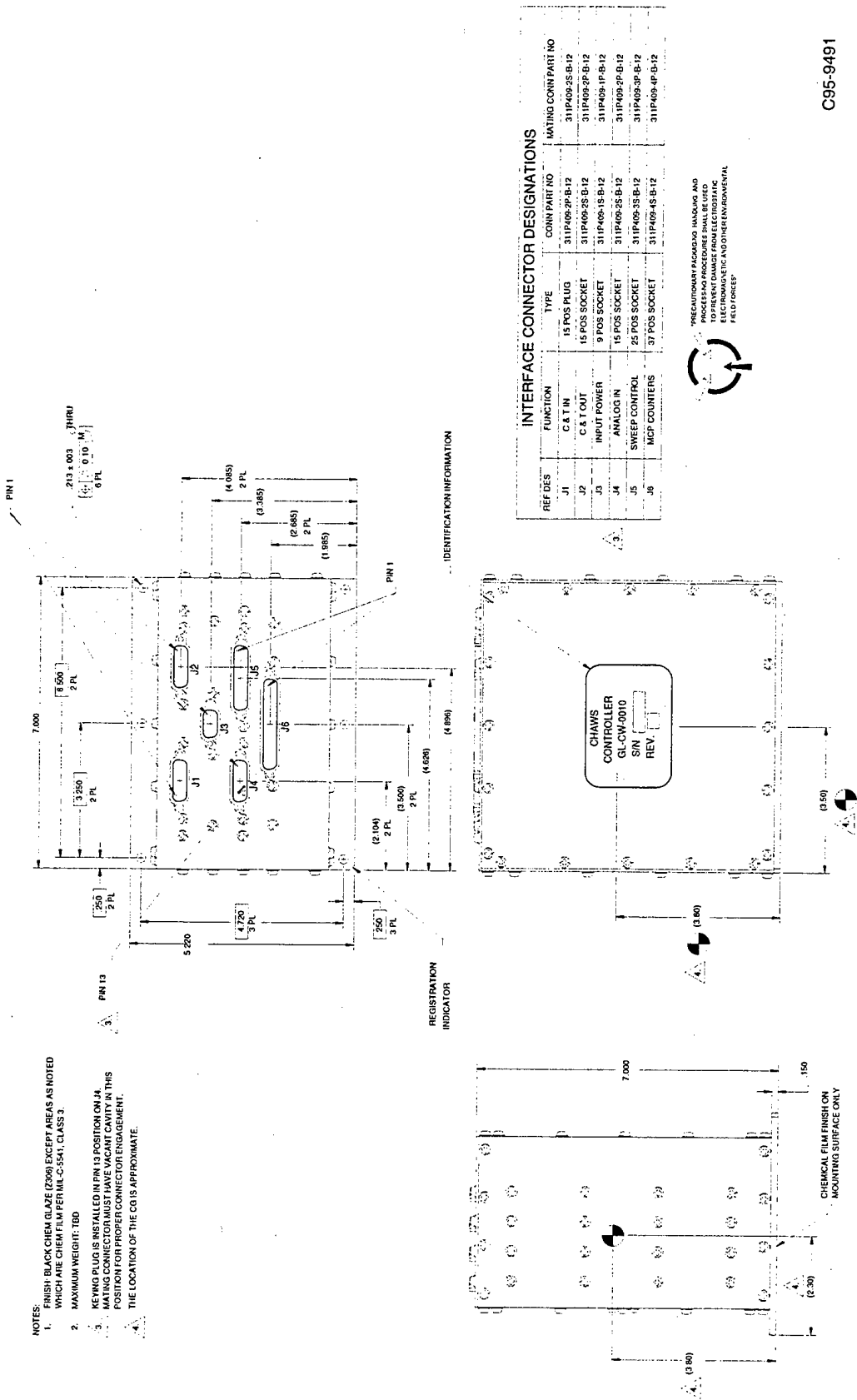


FIGURE 14: FMDS PLASMA SOURCE ELECTRONICS (PSE) ICD



C92-6211

FIGURE 15: VIEW OF CHAWS CONTROL ELECTRONICS



C95-9491

FIGURE 16: CHAWS CONTROL ELECTRONICS ICD

## 2.1.4 MATERIALS, PROCESSES AND PARTS

### 2.1.4.1 Materials

The nonmetallic materials used on the GCA Program include conformal coatings, adhesives, thermal conductive compounds, wire insulation and standard printed wiring board material. The preliminary materials list is provided in Table 1. These nonmetallic materials have been selected to comply with the standard space program criteria for total weight loss and vacuum condensable materials as well as to perform their designed function within the packaged unit.

TABLE 1  
GCA PROGRAM MATERIALS LIST

MATERIAL	SPECIFICATION	USE
Aluminum Alloy 6061-T6	QQ-A-250/11	Outer and inner housings
Chemical Film	MIL-C-5541, Class 3	Surface finish for mechanical part
Stainless Steel, 303	QQ-S-764	Hardware
Cond. A		
Plastic Sheet, Laminate	MIL-P-13949	Printed wiring boards
Copper Clad		
Molding Plastic (Diallyl Phthalate)	MIL-M-146 Type SDG	Connector Insulators, Transipads
Insulating Material	Dupont LP-392a	Screw insulator for mounting transistor
Epoxy	DOW DER332/TETA	Component Staking
Conformal Coating	Solithane 113/300	Printed wiring board assemblies, magnetics
Solder (Tin/Lead)	QQ-S-571	Electrical interconnections
Wire, Copper, Insulated	MIL-W-22759/28	Harness and interwiring
Wire, Copper Bus, Tinned	QQ-W-343	Harness and interwiring
Magnetic Wire	J-W-1177	Magnetic Devices
Sintered Iron	Manufacturer's Data Sheets	Magnetic Cores
Thermal Grease	MP0003413 (ATC) (TC-4)	Heat conduction enhancement
Sleeving, Heat-shrink	MIL-I-23053	Wire/lead insulation
Ink, Wornow	MIL-I-43553	Part serialization Unit identification

Metallic materials for the external and internal structure is 6061 alloy aluminum. Connector shells, electronic component cases and leads and the metal finishes have been selected to assure that intermetallic contact does not form galvanic couples and is corrosion resistant.

Flammability and toxicity hazards have been minimized. No cadmium, tin, or zinc will be utilized with the exception of necessary solder compounds.

#### 2.1.4.2 Processes

The processes being utilized on the GCA Program are well established and are implemented by properly trained, experienced personnel using controlled procedures proven to be acceptable for high reliability space programs. Table 2 lists the processes proposed for use in fabrication of the GCA. This table also lists the applicable ATC process control documents.

TABLE 2  
GCA PROGRAM PROCESSES LIST

MATERIAL	SPECIFICATION	USE
PWB Manufacturing	MIL-P-55110 MP0003404 (ATC) MP0003405 (ATC)	PWB Fabrication Vapor Degrease Cleaning Spray Cleaning
Soldering	MIL-S-45743	Electrical Interconnections
Passivation	MIL-F-14072	Surface Finish Hardware
Plating	MIL-C-5541 (Chemical Film)	Surface Finish Aluminum Parts
Epoxy Staking and Bonding	MP0003399 (ATC) (DER 332/TETA)	Component Mounting
Conformal Coating	MP0003400 (ATC) (Solithane)	PWB and Magnetics Coating
Component/IC Leads	MP0003402 (ATC)	Lead Cleaning and Forming
Wire Preparation	MP0003407 (ATC)	Wire Stripping
Wire Sleeving	MP0003634 (ATC)	Heat Shrink Sleeving
Components and Material (Handling)	MP0003411 (ATC)	ESD Controls

#### 2.1.4.3 Parts Program

ATC has selected parts for use in this program that have an established space application history and that assure its continued specification compliant performance over the mission.

#### 2.1.5 Real Time Data Acquisition System (RTDS)

##### 2.1.5.1 RTDS Overview

The Real Time Data Acquisition System (RTDS) was developed by ATC as the primary Ground Support Equipment (GSE) for the CRRES Microelectronics Package. The basic RTDS was designed to be readily adaptable to a wide variety of spaceborne control systems and is being modified for use as the FMDS GSE. The reduced requirements of the CHAWS Program did not require a full RTDS GSE. Therefore, simpler, lower cost GSE was developed for that program incorporating some of the RTDS features. A brief description of the FMDS GSE is presented in the following paragraphs.

The RTDS provides four main functions:

- Transmit commands to the FMDS
- Receive telemetry from the FMDS
- Logging all pertinent session data to disk for later analysis
- Translate (either in real time or batch mode) commands and telemetry

The interface is specifically designed for use with the FMDS. Large amounts of binary encoded information is generated

by the FMDS every orbit. Quick analysis of this information is tedious using standard procedures. RTDS is designed to eliminate tedium and allow for the quick assimilation and analysis of this data. The raw binary RTDS data is translated to readable text which contains the values in their proper units. This allows for fast, accurate analysis of the FMDS status and its associated experiments. Although designed to operate in a real time mode, analyzing data off-line is also supported by the RTDS.

The AT compatible computer was selected as the platform for the RTDS to provide a low cost, widely available, high performance computer which could meet the speed requirements of the real time FMDS data conversions. Direct connection to the FMDS is provided for by using the optional RTDS AT I/O card. The RTDS I/O card can be installed in any sixteen bit (full length) slot in the computer. The I/O card is optional and is not required for the software to function properly.

#### 2.1.5.2 RTDS Set-up

The RTDS is designed to simplify the sending of commands and interpretation of the telemetry going to and from the FMDS. During system start up, the software checks for the presence of the hardware I/O card. After the checkout is complete, the Main Menu screen will be displayed with the Setup option highlighted. Figure 17 illustrates the RTDS Main Menu Screen.

In all RTDS screens, the acceptable keystrokes for that screen are displayed in the corners of the border. Menu navigation is performed using the cursor keys. In all menus a status line is associated with each menu selection. This status line briefly describes the function selected.

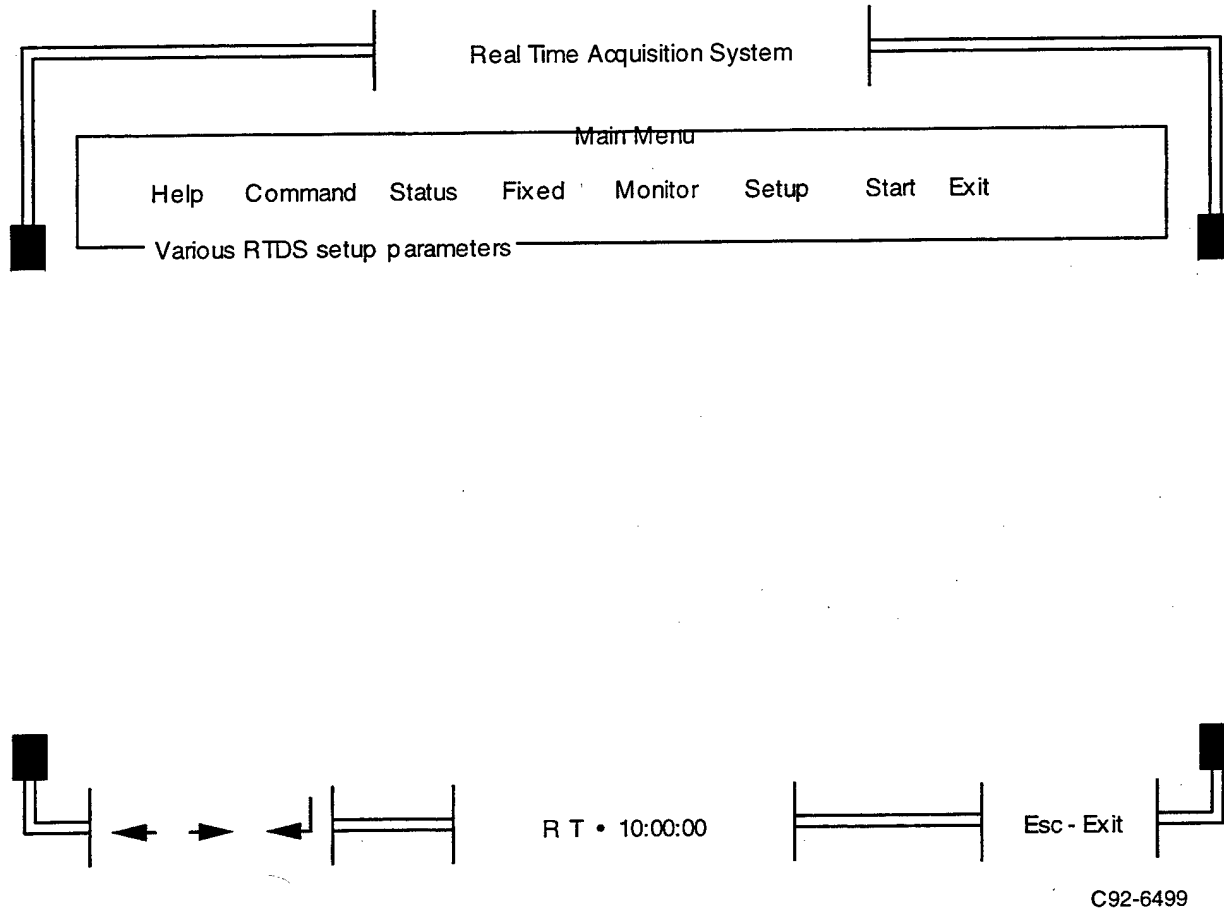


FIGURE 17: RTDS MAIN MENU SCREEN

There are two primary windows displayed in RTDS. The first is the user interface area. This area is always located at the upper portion of the screen. The second area is the Available Telemetry Window. The Available Telemetry Area is for displaying incoming RTDS telemetry, and is always located at the bottom of the screen. The Telemetry window will change size as the user exercises the various User Interface options.

RTDS initializes with the Main Menu screen displayed. Before the Interactive Command screen can be entered, the RTDS must be configured and Started. To configure the RTDS, the Setup menu is used.

Enter the Setup menu (Figure 18) from the Main Menu by moving the highlighted area to the SETUP entry and press enter. The Setup menu has six options:

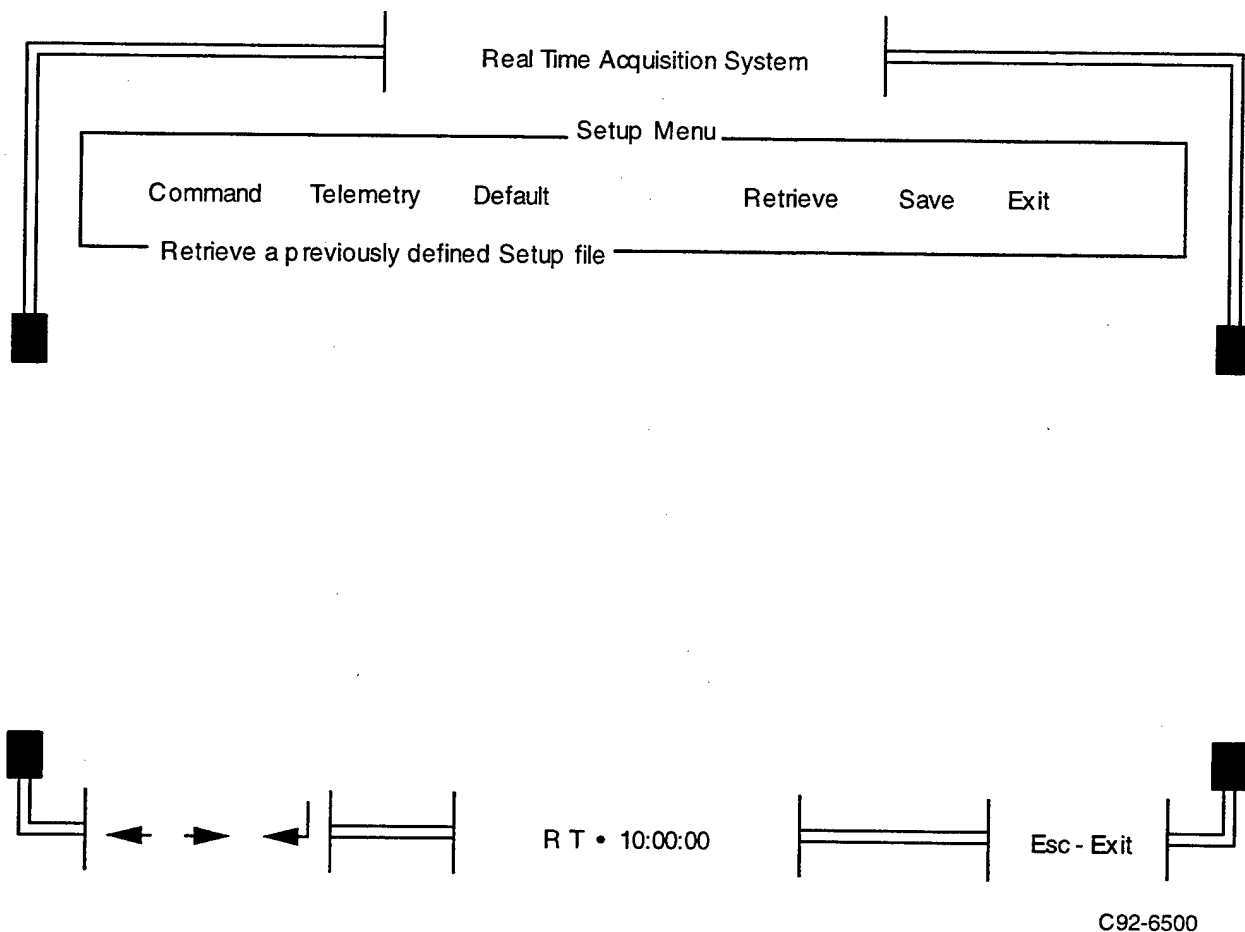


FIGURE 18: RTDS SETUP SCREEN

- Command - Setup default RTDS parameters for outgoing commands.
- Telemetry - Setup RTDS parameters for incoming telemetry.
- Default - Specify FMDS system default configuration parameters.

- Retrieve - Retrieves a previously defined setup file.
- Save - saves setup parameters to disk for future use.
- Exit - Returns user to the Main Menu.

#### 2.1.5.3 RTDS Operation

Before the RTDS can be used to operate the FMDS, it must first be configured (setup), as described in Section 2.6.2. After being setup, the RTDS must be started. Once started, the user can enter the Interactive Command screen by pressing the ESC key. To return to the Main menu from the interactive command screen, press F1.

The RTDS is started from the Main menu by placing the highlighted cursor on the Start entry and pressing ENTER. This will turn the FMDS off, toggle the FMDS relays to agree with the current Setup configuration, and then turn the FMDS back on. During the start-up sequence, the message "Turning FMDS Off" followed by "Turning FMDS On," will appear in a window in the upper right corner of the Main menu screen (Figure 19). This sequence of events will occur regardless of the presence of the RTDS I/O card. Once the FMDS is turned back on, the user will be returned to the Main menu screen. If the user has selected previously logged binary files as the input mode, the translation of these files will begin at this time. The user may now enter the interactive command screen, or perform other Main menu functions.

The primary screen of the RTDS is the Interactive Command Screen (Figure 20). The upper portion of the screen is the command entry area. The currently selected command title appears next to the Command prompt. A brief explanation of the command follows the command title. The Hex value of the first command word is shown two lines down. Pressing the PgUp or PgDn

keys will sequence the prompts through all possible FMDS commands. The sequence may be bypassed by entering the first word of the desired command.

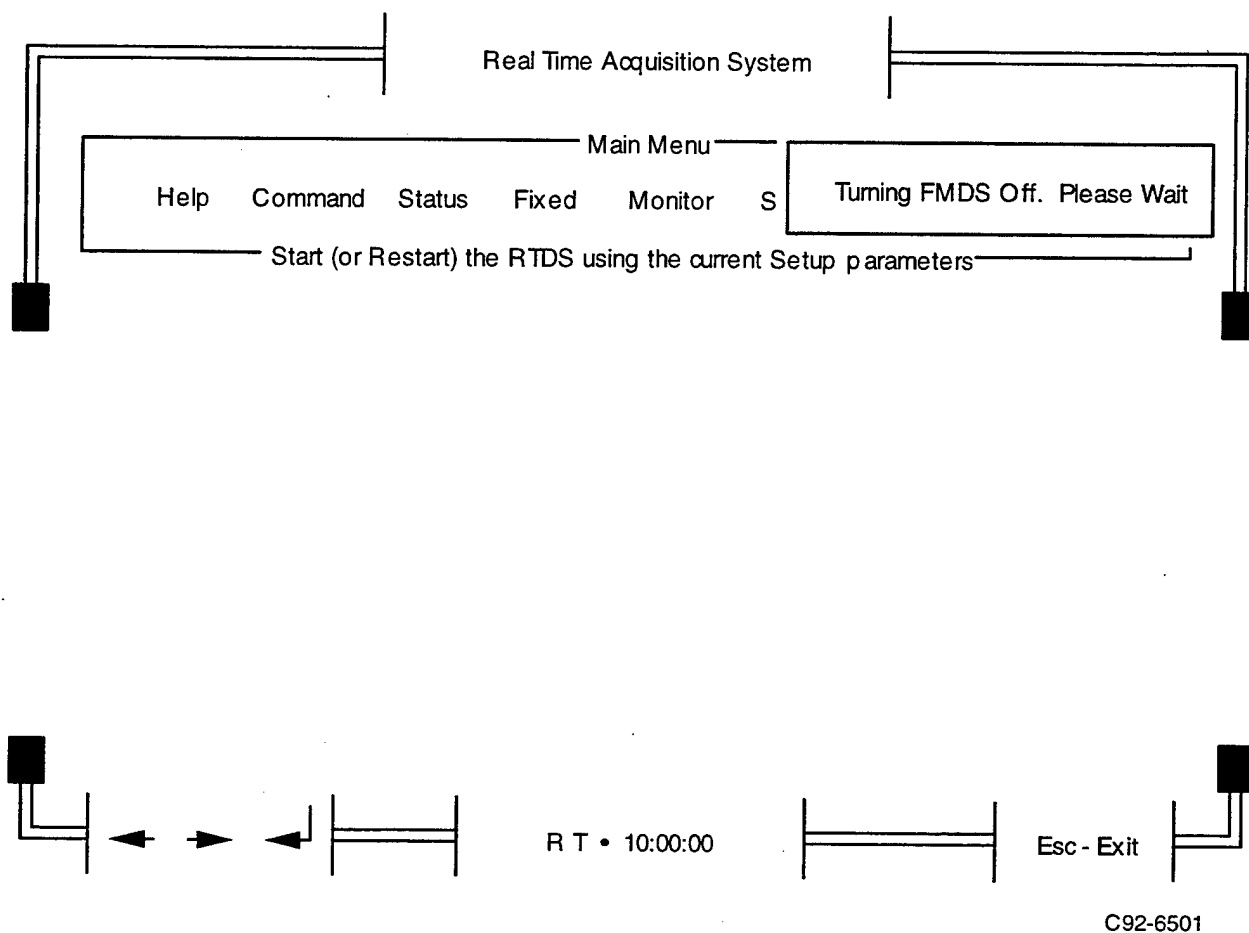


FIGURE 19: MAIN MENU DURING START-UP

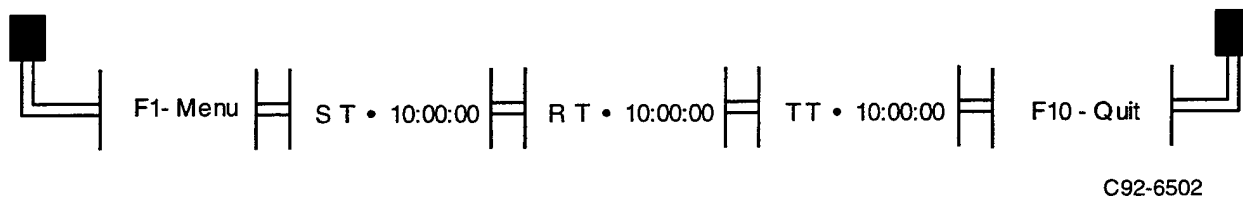
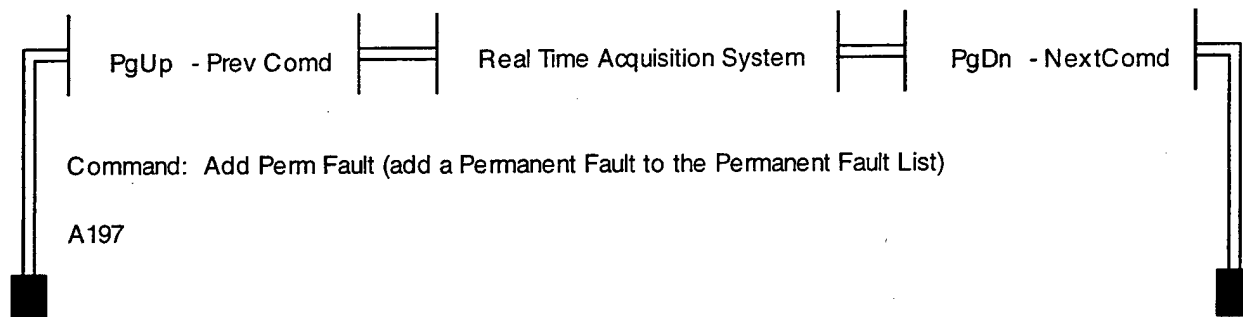


FIGURE 20: INTERACTIVE COMMAND SCREEN

Pressing Tab or Enter will place the user in the command entry sequence, either High or Low level, for that command. If the first word entered is an illegal command, the RTDS will briefly display the message "Unknown Command", beep, and return to the last legal command. Once the command word has been verified, the RTDS will display the one's complement of the command word. If the command is a multi-word command, the user will be placed in the command entry routine for that command. In the command entry mode, the current entry field will be highlighted. Command entry is now possible and the user can advance through the available fields (if any) by pressing Tab. This process will continue until the proper number of words have been entered for the selected command. After the proper number of words have been entered, the software will display the checksum for the command (if multi-word), and prompt the user before sending the command to the FMDS.

Pressing any key other than "Y" will abort sending the command and place the user back into the entry routine at the last field entered. Pressing Shift-Tab will backup the entry routine to the previous entry field.

If all fields of the command have been entered, pressing Enter within any field will terminate the entry procedure and display the Send prompt. A command may be aborted at any time by pressing the Escape key. The entry procedure will prompt the user before aborting the command.

All commands will be displayed in their Hex formats upon termination of the command entry routine for two reasons. First, this will help the user get acquainted with the Hex equivalent of a command (if in High Level entry mode). Second, this will provide a simple way of generating commands for further validation when the FMDS is not connected to the I/O card.

The commands available for use while in the interactive mode are listed in Table 3, with a brief description of each command.

#### 2.1.5.4 Real Time Status Display

This screen displays the current values of the FMDS Clock and Status flags. This screen is entered from the Main menu, by placing the highlighted cursor on the Status option and pressing Enter. This will cause the FMDS Clock and Status flags Status screen (Figure 21), to be displayed. The screen is updated once every two minutes when in the FMDS input mode.

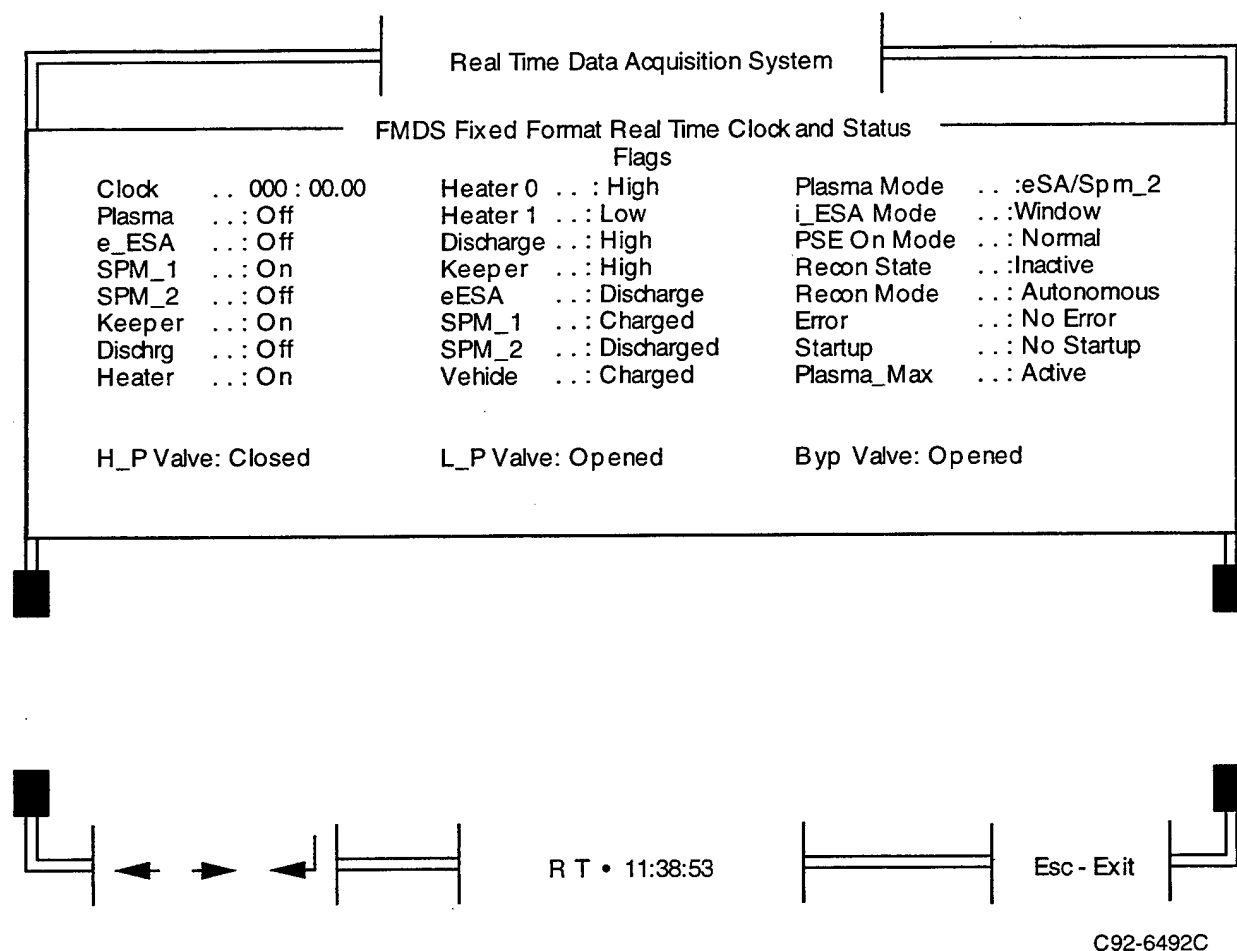


FIGURE 21: CLOCK AND STATUS FLAGS SCREEN

TABLE 3  
COMMANDS AVAILABLE TO THE RTDS

COMMAND	DESCRIPTION
SET REAL TIME CLOCK	Allows the user to adjust the value of the 32-bit real time clock
LOAD MEMORY	Allows the user to load data directly into the FMDS Controller memory
DUMP MEMORY	Allows the user to download data directly from the FMDS Controller memory
RESTART	Allows the ground to initiate a restart command to the FMDS Controller
CLEAR ERROR FLAG	Allows the user to clear the Controller Error Flag; this supports ground handshaking of internal controller errors.
BRANCH TO LOCATION	Allows the user to issue a BRANCH instruction to the FMDS microprocessor
RELAY CONTROL	Allows the user to manually control all the relays commandable by the FMDS Controller
START-UP ACKNOWLEDGE	Allows the user to clear the START-UP Flag in main frame zero fixed format telemetry
SET eESA SMOOTHING	Allows the user to adjust the number of times the eESA must register a charged condition before the controller reacts
SET eESA THRESHOLD	Allows the user to adjust the charge determination threshold for the eESA
SET SPM SMOOTHING	Allows the user to adjust the number of times a surface potential monitor must register a charged condition before the controller reacts
SET SPM THRESHOLD	Allows the user to adjust the charge determination threshold for the two surface potential monitors
SET PLASMA MODE	Allows the user to command the plasma source mode of operation
SET PLASMA ON/OFF	Allows the user to manually command the plasma source on or off
SET PLASMA ON MIN	Allows the user to adjust the minimum amount of time the plasma source is to be turned on
SET PLASMA ON MAX	Allows the user to adjust the maximum amount of time the plasma source is to be turned on
PLASMA MAXIMUM OVERRIDE CONTROL	Allows the user to enable or disable the override of the maximum amount of time the plasma source is to be turned on
SET PLASMA OFF TIME	Allows the user to adjust the minimum amount of time the plasma source will remain dormant between cycles

TABLE 3 (Continued)  
COMMANDS AVAILABLE TO THE RTDS

COMMAND	DESCRIPTION
RECONDITIONING CONTROL	Allows the user to start and stop the reconditioning of the plasma source
SET PLASMA CYCLE LIMIT	Allows the user to adjust the number of operating cycles of the plasma source generator prior to initiating reconditioning
SET PLASMA TRIES	Allows the user to adjust the number of turn-on attempts the controller will initiate prior to setting FAILURE_TO_TURN_ON Flag (thereby initiating atonomous reconditioning if enabled)
SET RECONDITIONING HEAT TIME	Allows the user to adjust the amount of time the controller will spend applying tip heat during a recondition cycle
SET RECONDITIONING MODE	Allows the user to enable or disable autonomous reconditioning
RESTART WINDOW	Allows the user to reset all window counters and rearm the acquisition to the current window parameters
SET WINDOW EVENT	Allows the user to choose which event will trigger the high resolution window data collection
SET WINDOW DELAY	Allows the user to alter the window delay time, which is the number of seconds to delay the action associated with the current window event
SET WINDOW RESOLUTION	Allows the user to alter the resolution of the window data packets
SET WINDOW DEPTH	Allows the user to set the absolute number of measurement sets the window option will store and download per event
EXECUTE PROM DIAGNOSTIC	Causes the FMDS to initiate the PROM checksum diagnostic
EXECUTE RAM DIAGNOSTIC	Causes the FMDS to initiate the indicated RAM diagnostic
EXECUTE WATCHDOG DIAGNOSTIC	Causes the FMDS to initiate the watchdog timer diagnostic
EXECUTE ADC DIAGNOSTIC	Causes the FMDS to initiate the analog-to-digital converter diagnostic routine

From the Main menu, placing the highlighted cursor on the Fixed entry and pressing Enter will invoke the FMDS Fixed Telemetry screen (Figure 22). This screen displays the current values of the FMDS Fixed Format Telemetry (minor frame zero). This screen is updated once every two minutes, regardless of input mode.

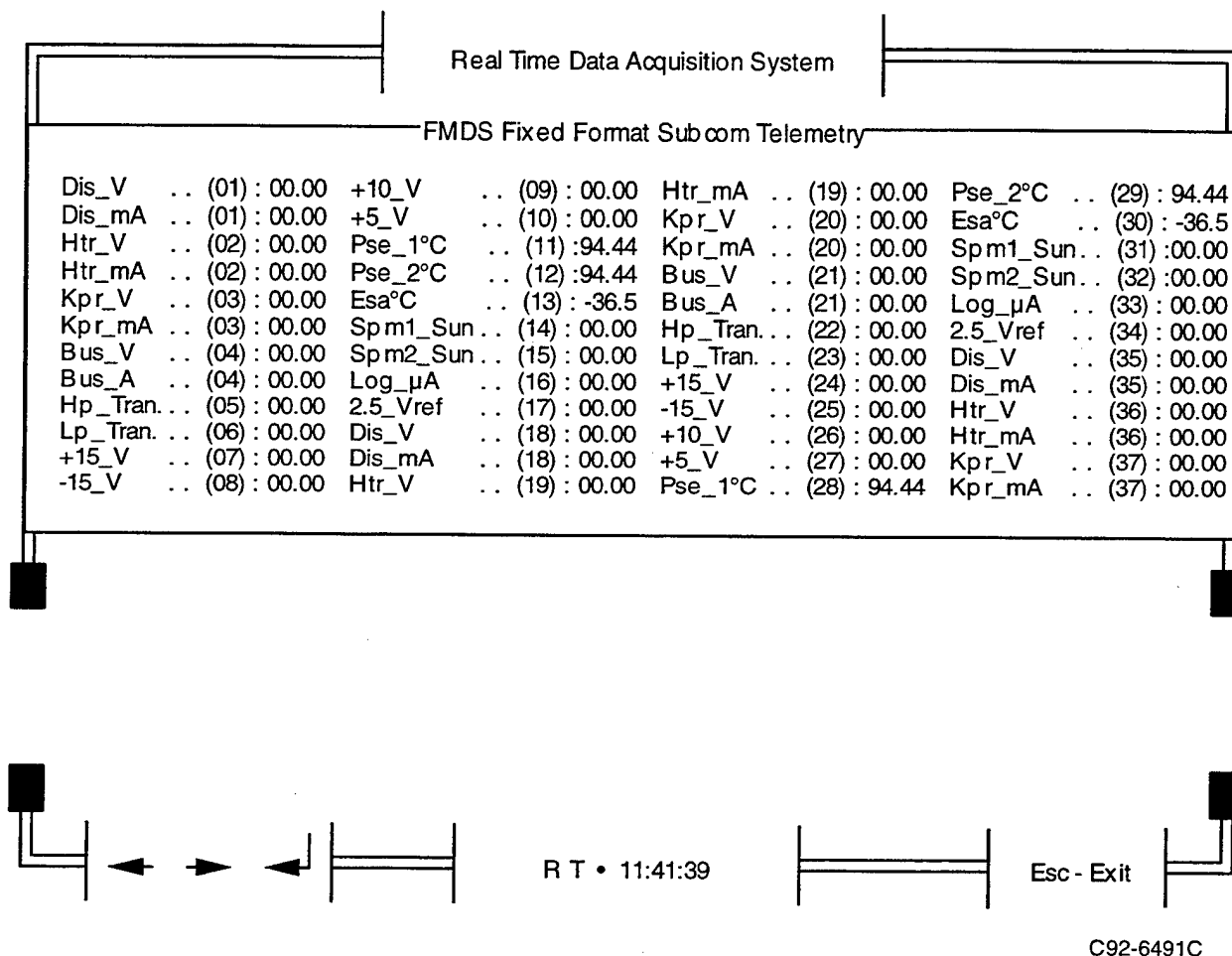


FIGURE 22: FIXED TELEMETRY SCREEN

#### 2.1.5.5 On-Line Printing

RTDS supports any PC compatible printer. The RTDS software also supports DOS re-direction of the line printer port to a serial port. Due to the Real-Time requirements of the RTDS, a high speed printer is required during Real time operation to support high error conditions.

#### 2.1.5.6 On-Line Help

To bring up the Help menu, place the highlighted cursor on the Help entry in the Main menu and press Enter. There are two areas of HELP supported, RTDS and GENERAL FMDS. The RTDS help option will explain basic FMDS theory and operation. When using the Help screens, the PgUp and PgDn keys are used to browse the Help text. Pressing escape will return the user to the Help Menu.